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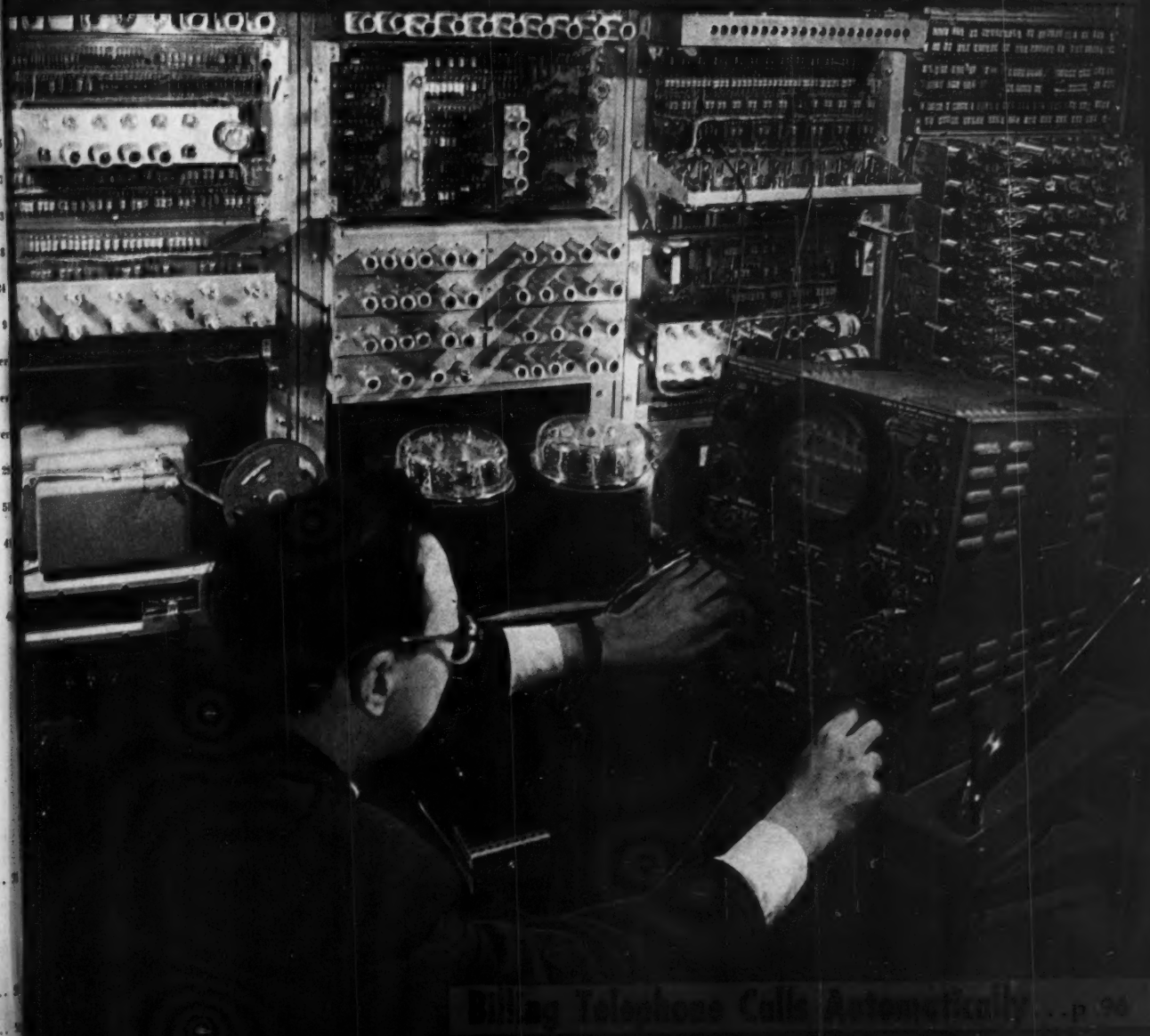

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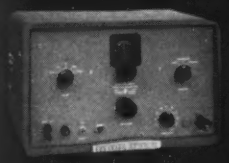
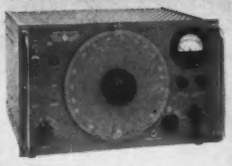
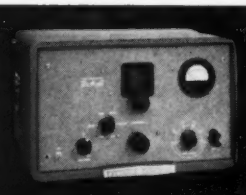


202A—for vibration analysis, servo tests, other vlf measurements. 0.008 to 1,200 cps. Output 20 mw/10 volts. $465.00

200CD—popular precision instrument for audio and ultrasonic tests. 5 cps to 600 KC; output 160 mw/10 volts; 20 volts open circuit. $160.00

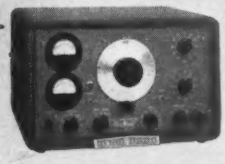


233A—carrier test oscillator covering frequencies 50 cps to 500 KC. Output 3 watts/600 ohms. $475.00



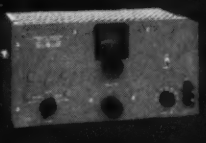
650A—highly stable, wide band; 10 cps to 10 MC. For audio, supersonic, video, rf measurements. Output 15 mw/3 volts. Frequency response flat ± 1 db. $490.00

200AB—for audio tests, 20 cps to 40 KC. Output 1 watt/24.5 volts. Simple to use, compact, rugged. $130.00



205AG—time-tested convenience for high power tests, gain measurements. 20 cps to 20 KC, 5 watts output. $440.00

206A—widely-used for high quality, high accuracy audio tests. Very low distortion. Covers 20 cps to 20 KC; output ± 15 dbm. $565.00



200T—custom-engineered for telemetry, carrier current tests. 250 cps to 100 KC, output 160 mw/10 volts; 20 volts open circuit. $350.00

207A—low cost sweep oscillator, continuous output 20 cps to 20 KC, flat response, low distortion. May be motor driven, or coupled to recorder. $275.00

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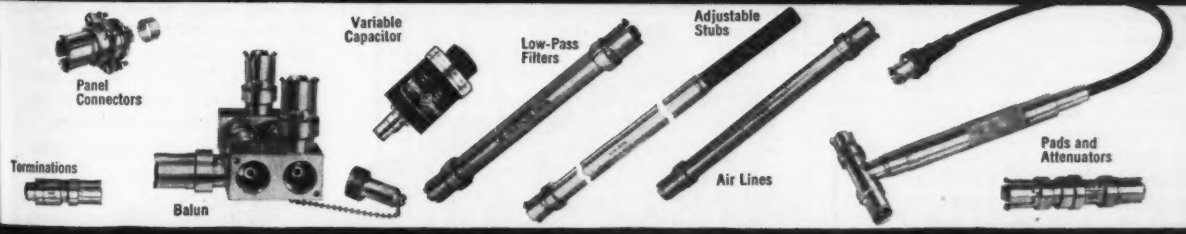

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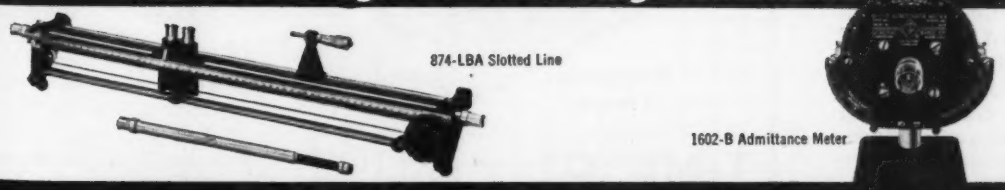

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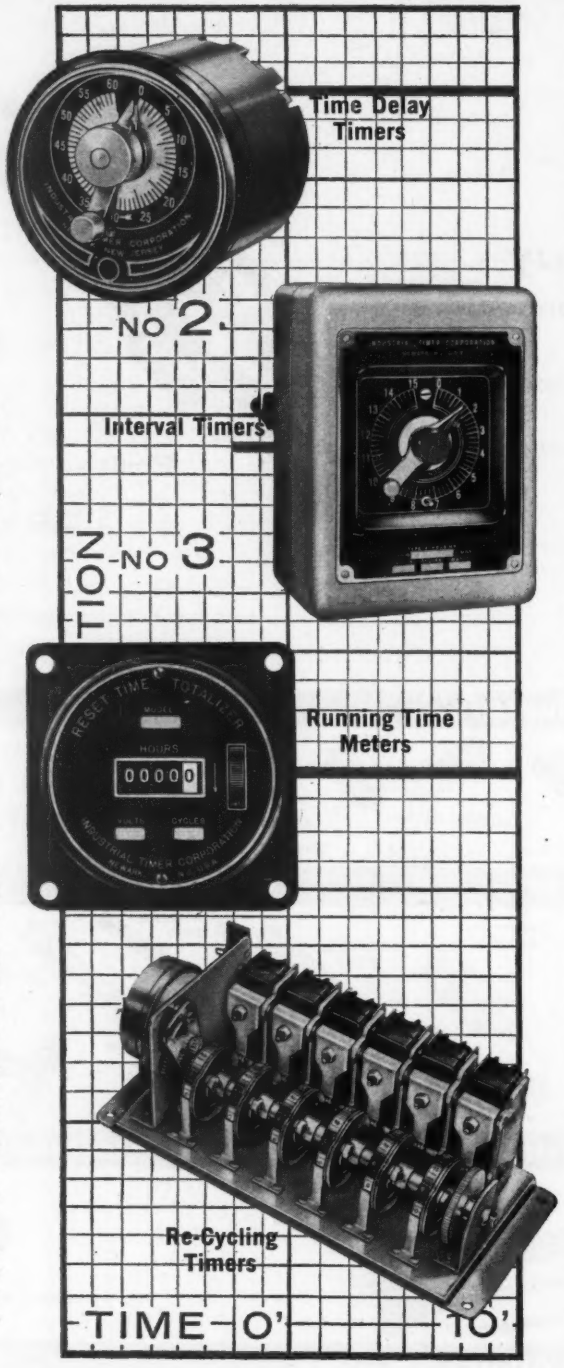

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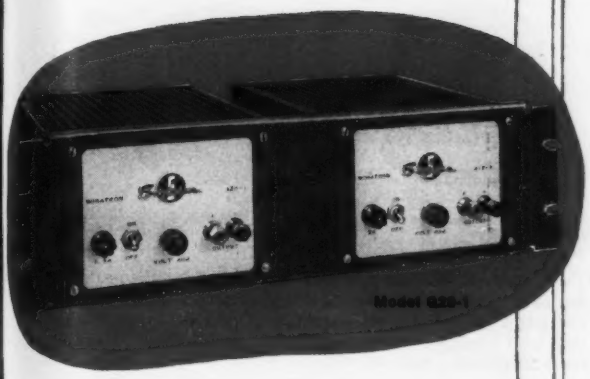

Model Q28-1
Output: 18 to 36 (28 nominal) VDC, 0 to 1 amp.
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Ripple: 0.01% maximum
Response time: 50 microseconds
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Model Q6-2
Output: 4.5 to 8 (6 nominal) VDC, 0 to 2 amps.
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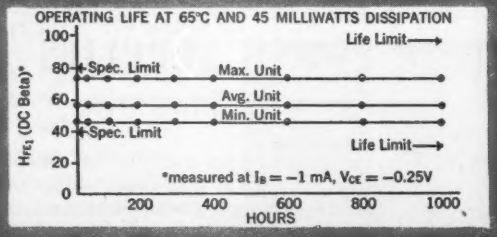
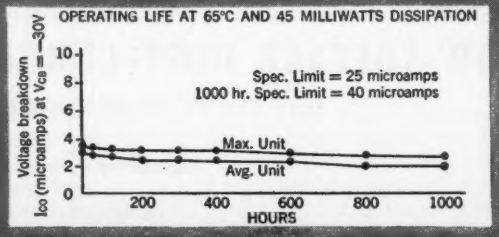
Two hundred of these Transistors (fifty of each type) produced no failures and negligible characteristic change in thousand hour life tests equally divided between operation and storage. Here are typical results for 25 units, type 2N427:




OPERATING LIFE AT 65°C AND 45 MILLIWATTS DISSIPATION
Spec. Limit = 25 microamps
1000 hr. Spec. Limit = 40 microamps
Max. Unit
Avg. Unit
Voltage breakdown I_{CO} (microamps) at $V_{CB} = -30V$
HOURS

1000 hour storage life tests at 85°C are equally satisfactory

I_{CO} is measured at maximum rated collector-base voltage. Life tests for I_{CO} and I_{EO} demonstrate that the maximum ratings for V_{CB} and V_{EB} do not decrease with life. All other electrical characteristics important in computer applications are equally well controlled. In addition to the usual 25°C tests, H_{FE} is controlled at −55°C and at +70°C while I_{CO} is also checked at +70°C.

In addition, all these Raytheon Computer Transistors measure up to such rigid MIL-T-19500A mechanical and environmental requirements as:

LEAD SOLDER DIP TEST (par. 4.6.23)
TEMPERATURE CYCLING: 5 cycles from −65°C to +160°C (par. 4.6.24)
MOISTURE RESISTANCE: tests hermetic seal (par. 4.6.26)
SHOCK: 500G (par. 4.6.28)
CENTRIFUGE: 20,000G (par. 4.6.29)
VIBRATION (Fatigue): 10G, 60 cycles (par. 4.6.30)
VIBRATION (Noise) (par. 4.6.31)
SALT SPRAY (Corrosion) (par. 4.6.35)
LEAD FATIGUE (par. 4.6.36)

Type	V_{CB} max. volts	V_{CE} max. volts	$f_{\alpha b}$ ave. Mc	H_{FE_1} ave. $I_B = 1$ ma $V_{CE} = -0.25V$	H_{FE_2} ave. $I_B = 10$ ma $V_{CE} = -0.35V$	Rise Time* max. μsec	Dissipation Coefficient In Air °C/mw	Dissipation Coefficient In Sink °C/mw
2N425	−30	−20	4	30	18	1.0	0.4	0.18
2N426	−30	−18	6	40	24	0.55	0.4	0.18
2N427	−30	−15	11	55	30	0.44	0.4	0.18
2N428	−30	−12	17	80	40	0.33	0.4	0.18

*$I_C = 50$ ma; $I_{B_1} = 5$ ma; $R_L = 200\ \Omega$; $I_{B_2} = 5$ ma; Grounded Emitter Circuit; T = 25°C

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ELECTRONICS NEWSLETTER

● **Chief scientist** of USAF ballistic missiles program, Simon Ramo, indicated last Thursday that advanced computers may be more important in a race for survival than space supremacy.

"Total brainpower," Ramo told the AIEE winter general meeting in New York, will determine scientific progress. "That brainpower is not set just by the number of human brains in each nation, but rather how these brains are used and how they are supplemented by synthetic intelligence devices. I think we are ahead of the Russians today in the techniques that extend and make more useful each brain and each pair of eyes."

● **Still no word** on who's to direct Defense Department's Advanced Research Projects Agency. Guided missile director Holaday is serving temporarily. Although Secretary McElroy has not yet spelled out agency's duties, strong fears have already been expressed such an agency might be too powerful.

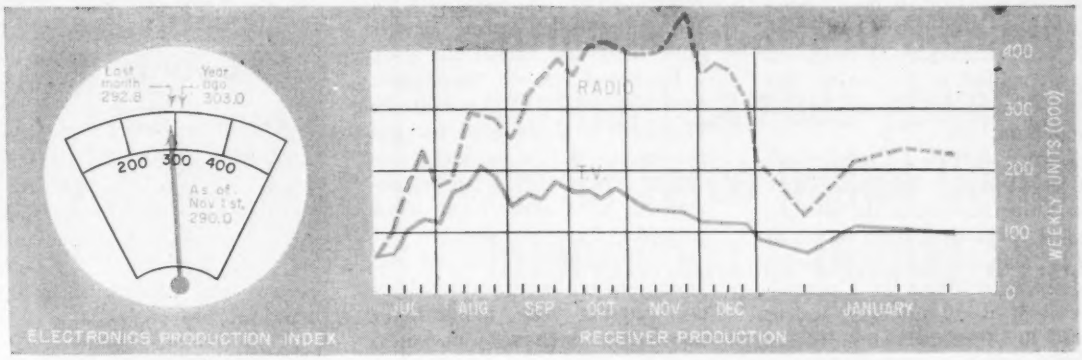
Principal criticism of the proposed space agency is that it might tend to play down the peaceful aspects of space research, concentrate only on anti-missile missile and other military work. Many believe the two should be separated. Sen. Clinton P. Anderson (D., N.M.) and Rep. Carl T. Durham, (D., N.C.), for example, want the Atomic Energy Commission to have authority over a space-for-peace program. They have introduced legislation to this effect.

Then there is support also for the thesis of the National Advisory Committee for Aeronautics, which wants to engage in a "cooperative effort" with the Defense Department, National Science Foundation and National Academy of Sciences. **NACA is concerned lest the need for space research for peaceful purposes becomes "submerged" from the public view.**

● **American-Soviet accord** providing for exchanges of technicians, teachers and others, appears to stay clear of electronics. Iron and steel, iron ore mining and plastics are among the industries singled out.

Agreement also calls for reciprocal visits by scientists, but does not spell out any specific fields. These details will be settled in Moscow this year by the presidents of the National Academy of Sciences of the U. S. and the Soviet Academy of Sciences. **Individual and group exchanges are in addition to attendance by U. S. and Russian scientists at international conferences in both countries.**

● **Defense Department is up in the air on atomic planes.** Joint Congressional Atomic Energy subcommittee's hearing of Deputy Defense Secretary Quarles has been postponed until the middle of this month at the department's request to allow more time for a decision on how to proceed.



FIGURES OF THE WEEK

RECEIVER PRODUCTION

(Source: EIA)	Jan. 24, '58	Jan. 17, '58	Jan. 25, '57
Television sets, total	103,444	108,806	111,921
Radio sets, total	232,845	239,133	302,863
Auto sets	80,036	79,578	147,948

STOCK PRICE AVERAGES

(Source: Standard & Poor's)	Jan. 29, '58	Jan. 22, '58	Jan. 30, '57
Radio-tv & electronics	46.14	44.92	47.38
Radio broadcasters	59.08	58.25	63.06

FIGURES OF THE YEAR

	1957	1956	Totals for first 11 months Percent Change
Receiving tube sales	428,688,000	429,846,000	— 0.3
Transistor production	25,965,000	11,232,000	+131.2
Cathode-ray tube sales	9,076,982	10,191,545	— 10.9
Television set production	5,825,804	6,760,045	— 13.8
Radio set production	13,634,402	12,266,591	+ 11.2

LATEST MONTHLY FIGURES

EMPLOYMENT AND PAYROLLS

(Source: Bur. Labor Statistics)	Oct. '57	Sept. '57	Oct. '56
Prod. workers, comm. equip.	412,000-p	417,900-r	413,100
Av. wkly. earnings, comm.	$76.44 -p	$78.40 -r	$78.12
Av. wkly. earnings, radio	$74.40 -p	$76.02 -r	$75.70
Av. wkly. hours, comm.	39.0 -p	40.0 -r	40.9
Av. wkly. hours, radio	39.0 -p	39.8 -r	40.7

TRANSISTOR SALES

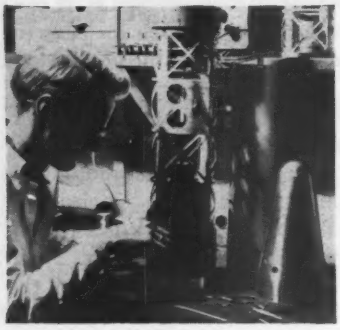
(Source: EIA)	Nov. '57	Oct. '57	Nov. '56
Unit sales	3,578,700	3,544,000	1,829,000
Value	$6,989,000	$7,075,000	$5,559,000

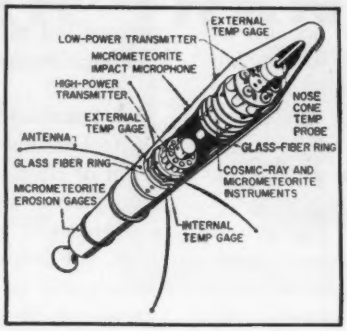
TUBE SALES

(Source: EIA)	Nov. '57	Oct. '57	Nov. '56
Receiving tubes, units	39,950,000	47,075,000	39,489,000
Receiving tubes, value	$33,166,000	$38,421,000	$31,476,000
Picture tubes, units	772,801	995,629	957,765
Picture tubes, value	$15,138,438	$19,495,574	$16,014,839

Vanguard Gear In Explorer

Army's globe-circling satellite carries Navy circuits. Here's a roundup of electronics' role as U. S. moon parade begins





Explorer I's instruments (left) get a final checkup before roaring aloft. In artist's sketch (right) instrumentation in the earth-circling U. S. satellite is identified.

FIRST of Army's satellites, Explorer I, is carrying out the intended mission of Navy's second satellite, using measurement circuitry originally planned for Vanguard II, ELECTRONICS learns.

Circuitry, developed for the spherical Vanguard II by Air Force Cambridge Research Center and the State University of Iowa, has been modified to fit into its new javelin-like Army carrier by Jet Propulsion Labs.

Carried aloft by a Chrysler-built Jupiter-C, guided by Ford Instrument's inertial system, the satellite, locked to its final stage rocket, is 79 in. long and 6 in. in diameter. Total weight is 30.8 lb. The satellite itself is 30 in. long, weighs 18.13 lb. Instrumentation weighs 11 lb.

Explorer I is investigating three areas: cosmic rays, density and size of micrometeorites, and temperatures both inside and outside the satellite's shell. (Mission for Explorer II is the same, though a different telemetering technique is employed.)

As for Vanguard satellites, plans now call for firing four of the originally-scheduled five 20 in. spheres. Officials say Vanguard II will be skipped, since Explorer I is performing its duties. Vanguard I is primarily concerned with ultraviolet radiation.

. . . For Measuring Temperatures . . .

LOS ANGELES—CAL TECH's Jet Propulsion Labs' major contribution was putting the satellite together. It was also responsible for the temperature sensing devices both inside and outside the shell.

Explorer I has two transmitters, each powered by its own batteries (Explorer II is designed for one transmitter. A tape recorder is carried to store data that can be telemetered in a short burst when queried.) Explorer I details:

(1) Frequency — 108.00 mc; power—10 milliwatts; expected life two months, data transmitted—skin temperatures on forward area, nose cone during launching, cosmic rays, micrometeorites.

(2) Frequency — 108.03 mc; power—60 milliwatts; expected life —two weeks; data transmitted—skin temp on rear area, internal temp, cosmic rays, micrometeorites.

External skin temperatures are expected to range from −100 C to +140 C. To maintain an average inside temperature of from 0 to 50 C, the forward area of the satellite shell is partially covered with 8 strips of zirconium oxide, each ¼ in. wide. Also, an insulating space exists between the outer skin of the shell and the glass fiber that surrounds the instruments.

The entire electronic package was tested to withstand up to 100 G's.

. . . Getting Data This Way . . .

WASHINGTON—PROCEDURE for tracking and calculating Explorer I's orbit is the same as set up for Vanguard and later used for the two Soviet Sputniks.

Twelve Minitrack stations send in position reports to the Naval Research Laboratory. Position data culled for reliability is sent on by NRL to the IBM Computing Center. A 704 computer calculates and forecasts the satellite's orbit.

Experiment data are recorded on magnetic tapes at the Minitrack stations and also at six Microlock tracking stations around the world. Tapes are then sent to Jet Propulsion Labs in Los Angeles and to IGY headquarters in Washington. Data from all experiments are recorded and forwarded to the corresponding sponsoring agency.

. . . Counting Cosmic Rays . . .

IOWA CITY, IOWA—DATA on cosmic rays are being received by the State University of Iowa's James A. Van Allen. A continuous cosmic ray count is measured by a Geiger counter and telemetered by both transmitters.

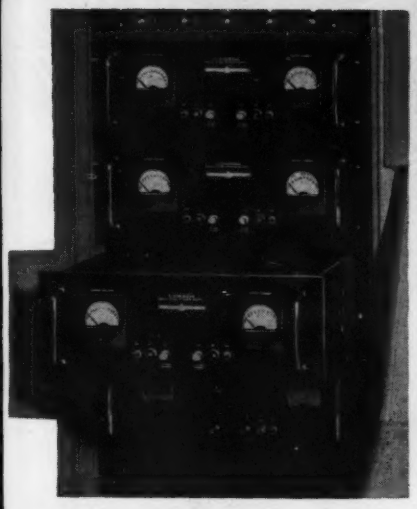
Total count of cosmic rays hitting the Geiger counter has been scaled down by 32 so that each unit of the 32 cosmic ray count will cause a step change in frequency. Average counting rate produces approximately 32 pulses a second, which causes a frequency change once each second.

The system is capable of transmitting cosmic-ray information at 40 times the normal rate if such activity occurs during intense solar or magnetic storms.

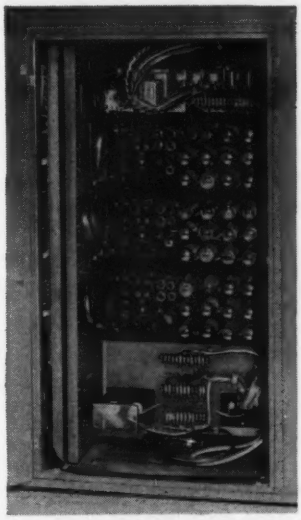
Explorer II carries the same equipment.

First cosmic ray data—showing 20 counts per second—came from

Digital Computer Intervention and Display System designed and fabricated by Stromberg-Carlson Company, a Division of General Dynamics Corporation, for the Air Proving Ground Center (ARDC) Armament Division, Eglin Air Force Base. The system is built around the CHARACTRON* Shaped Beam Tube, designed by Stromberg-Carlson for high-speed information display and micro-film recording.



C-800 Lambda Com-Pak Power Supplies used in the Eglin Air Force Base installation require only 7" front panel height.



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C-800 series—	800 MA—	7" panel height—from	315.00
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Stromberg-Carlson specifies standard Lambda power supplies for Air Force Digital Computer Intervention & Display System

Standard Lambda power supplies are components of the Digital Com puter Intervention and Display System associated with the UNIVA(Scientific Computer at the Air Proving Ground Center (ARDC) Arma ment Division, Eglin Air Force Base, Florida.

Available for immediate delivery, Lambda power supplies from stocl are being used in major rocket and missile programs, among othe military projects. They are specified also for more industrial and re search applications than the ten next-most-popular makes combined.

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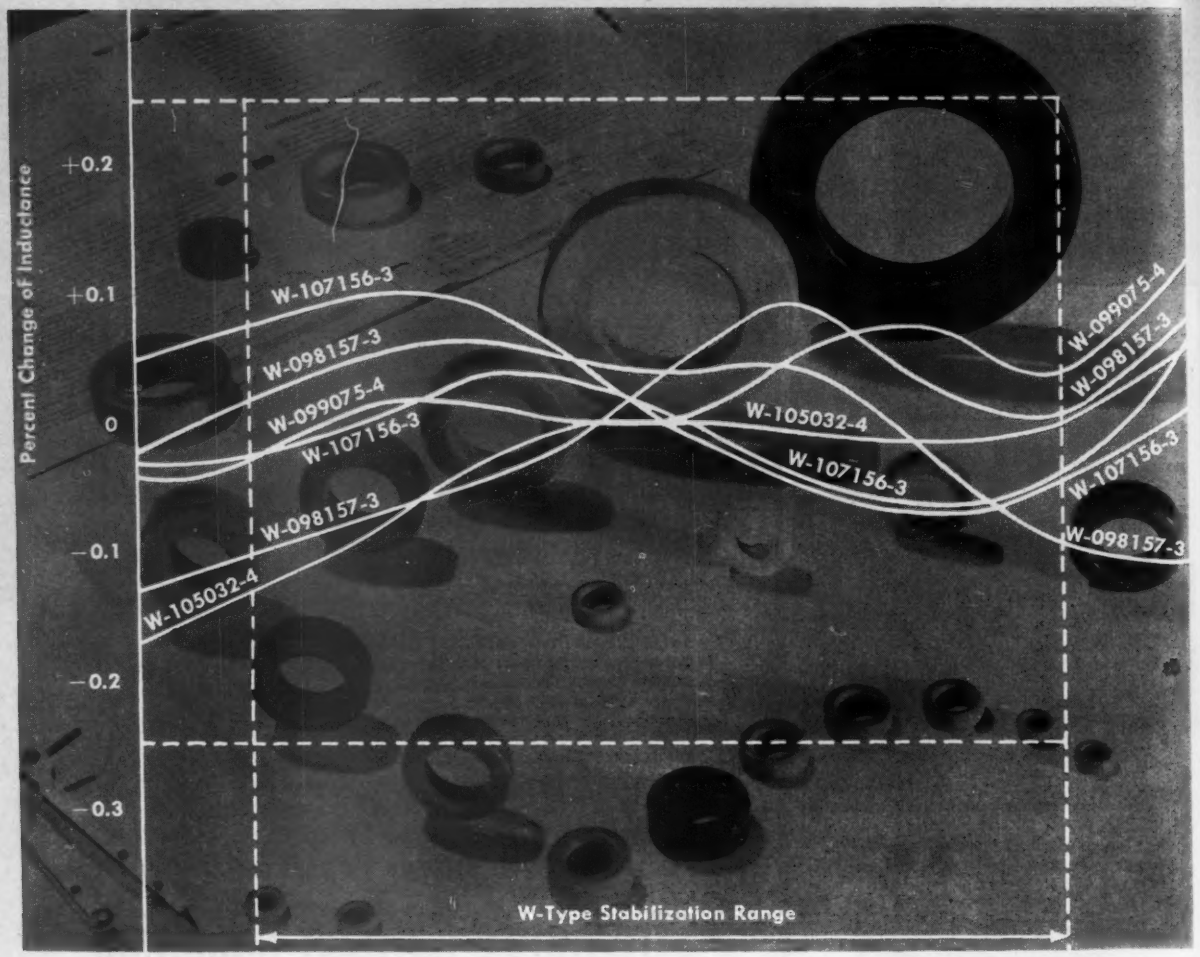
CIRCLE 73 READERS SERVICE CARD



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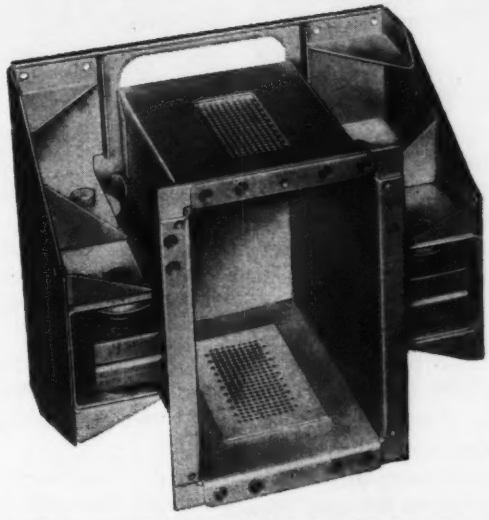
PROBLEM

VIBRATION • SHOCK AND COOLING

GUIDED MISSILE RELIABILITY

PROTECTION OF FUEL CONTROL EQUIPMENT from destructive vibration and shock in high temperature propulsion section of IRBM missiles.

SOLUTION



MODEL 1322 FOR REDSTONE AND JUPITER MISSILES
developed and produced in quantity for Redstone Arsenal and Chrysler Corporation.

ENGINEERED MOUNTING SYSTEM

MODEL 1322:

Robinson Model 1322 is a center-of-gravity all-metal mounting. Providing consistent performance regardless of high or low temperature extremes, this design incorporates highly damped Met-L-Flex resilient elements. All-attitude, multi-directional protection is assured.

SPECIAL FEATURES:

1. Ventilation screens at top and bottom of mounting enclosure allow the flow of cooling air, thereby extending the range of environmental protection.

2. Versatile mounting design facilitates adaptation to a wide range of components of varying dimensions.

PERFORMANCE:

Model 1322 protects against the rugged environment in the propulsion section of large rocket-type missiles. **Vibration, shock and acceleration forces** are controlled by the mounting system through a careful combination of spring rate and damping design characteristics. Natural frequency of model shown is 16 c.p.s. for an impressed excursion of .060 ins. and equipment weight of 8 lbs.

RESULT:

Adequate protection provided and reliability accomplished for vital elements of fuel control equipment through a light-weight standardized mounting system design. (Approximately six (6) systems installed in each Jupiter missile.)

ROBINSON CONTROL IS RELIABILITY CONTROL

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. . . Systems Get Meteor Facts . . .

BOSTON—DATA on the size and density of micrometeorites are being studied at the Geophysics Research Directorate, Air Force Cambridge Research Center.

Explorer I uses two systems to get the data: grid detectors that determine density, and an acoustic system that detects size as well as density. They were developed respectively by Edward Manring and Maurice Dubin.

(1) Density: 12 grids are arranged on an insulated ring that goes around the aft, outside portion of the satellite, flush with the skin. Each grid has a total surface of one sq cm and consists of 500 windings.

When a micrometeorite larger than 1/100,000 in. smashes into it, the continuous filament breaks. This causes a small increase in frequency in the low-power transmitter.

Since the surface area of each grid is known, the number of collisions that strike during any certain time indicates, by arithmetic, the density of meteoritic particles in the space through which the satellite has moved. (Four grids were broken immediately after launching. Whether due to launching shock or to micrometeorites can best be judged later by what happens to the remaining eight.) System weighs 10 oz.

(2) Density and size: The 16-oz acoustical detector consists of a crystal microphone mounted against the skin of the satellite and connected to an amplifier and scaler. The microphone is in spring contact with the outer shell of the satellite.

When a particle of sufficient size and momentum hits the shell, the amplified pulse actuates the scaler. Output of the scaler controls the frequency of one telemetry channel of the high-power transmitter. When frequency changes from low to high it means the satellite has hit a large particle.

The device is capable of detecting a wide range of particle sizes

WASHINGTON OUTLOOK

A NEW TREND in weapon development and production has gently started. It could put more small and medium-sized firms in the running for prime defense contracts for important new weapons systems.

Idea involves organizing a team of specialty companies to make a joint bid on a systems contract. So far, the Air Force has awarded two such development contracts:

Stavid Engineering, Inc., last July was awarded a phase-one prime contract for development of a defensive antimissile system, project DAMS (ELECTRONICS, Nov. 20, '57). Stavid is both the system contractor and the electronic specialist on the project. Its team members—they are not subcontractors in the conventional sense—are Olin Mathieson Chemical Corp., Bausch & Lomb Optical Co. and United Shoe Machinery Co. Last December, the team—in Stavid's name—was awarded a phase-two contract for more advanced development work.

Last month, Hoffman Electronics Corp. (ELECTRONICS, Nov. 10, '57) was awarded an $11-million prime contract to develop a complete airborne electronic reconnaissance system known as Tall Tom. Its team members: Stanford Research Institute, Sanders Associates, Cornell Aeronautical Lab., Filtron Co., Inc., Radiation, Inc., Siegler Corp.'s Olympic Radio & Television div., and Lockheed Aircraft Services, Inc.

In Stavid's case, the electronics company negotiated with the Air Force for the group, and assumed complete responsibility for performance on the contract. Among themselves, however, the four companies agreed that each was to have an equal say in the management of the overall project.

● The Pentagon has made what many observers consider a puzzling decision on how to run the anti-ICBM defense project. Defense Secy. McElroy has divided responsibility on the project between the Air Force and Army.

To the Air Force goes responsibility for developing early warning and defense acquisition radars and data handling equipment. To the Army goes responsibility for working on the missile itself, the launching system and target tracking radars.

Up to now, the two services have each backed up a complete anti-ICBM system: the Army, the Nike Zeus under development by Western Electric and Douglas Aircraft; the Air Force, the Wizard under development by RCA and General Dynamics' Convair div.

The Nike Zeus project got started earlier, as an outgrowth of the two operational Nike Ajax and Nike Hercules air defense systems. The project's head start over Wizard is considered the basic reason for McElroy's new decision.

Some critics—notably Air Force partisans—question the advisability of separating the two functions, argue that this will slow down development of a total anti-ICBM defense system. Indeed, some observers look at the decision as an interim one which will be more fully resolved when the Defense Dept.'s new Advanced Research Projects Agency opens shop. ARPA has been delegated responsibility for the project, but has yet to start operations as an agency independent of the military services. Service opposition—plus some unanticipated and unfavorable Congressional reaction—have delayed ARPA's official organization.

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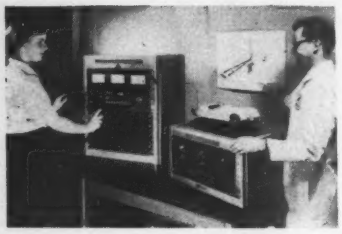
of moderate density, almost down to the size at which cosmic or meteoric dust is blown out of the solar system by radiation pressure—one micron.

When Vanguard, which failed again Feb. 5, does go up, it will transmit on the same frequencies as Explorer. No confusion is expected, since the satellites' orbits will differ.



Corrective driving motions introduced through steering wheel to computer (left) cause miniature car on simulator (right) to give immediate visual indication of vehicle response as . . .

Analog Helps Design Autos

RESPONSE CHARACTERISTICS of steering and control systems for automobiles are now studied before the actual design phase begins. Technique using an analog computer resembles, in principle, that used by aircraft designers who fly synthetic airplanes mathematically.

The new device, developed by GM's research staff, simulates an auto moving down a highway.

Equations representing lateral vehicular motion have been developed. They mathematically describe entire steering or handling system response to driver reactions.

Continuous solution of the equations is effected by the analog computer for any steering wheel input parameters. The computer is linked to an automobile handling simulator which controls a miniature car through a servomechanism system.

Cars of different weight distribution, suspension properties, wheel bases or tire characteristics can be accommodated by adjustment of controls on the computer.

MILITARY ELECTRONICS

• **Prevailing atmosphere** among industry and government officials at New York's Institute of the Aeronautical Sciences' 26th Annual Meeting was impatience to get on with the big push ahead. Tempering this, however, was the healthy attitude that red-tape delays could be put to good use. Initial planning could be restudied for possible improvement.

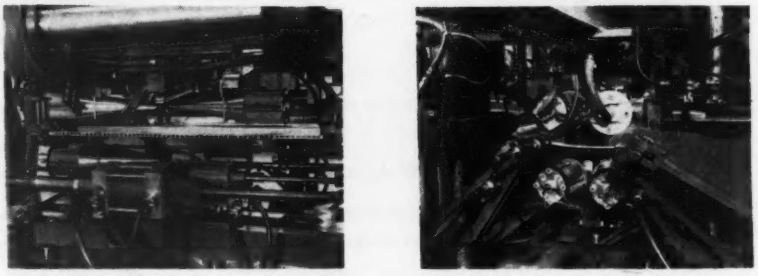
• **Electronic countermeasure** equipment for Boeing's B-52 long-range bomber is described as "revolutionary" by USAF Gen. Levine. Sperry is ECM weapon system manager, responsible for development and production.

• **Digital fire control computers** for Minneapolis-Honeywell's anti-submarine rocket ASROC (ELECTRONICS, Dec. 1, '57) will be built by Librascope under $12-million Navy contract.

• **Electronic reconnaissance system,** designated Tall Tom (AN/ALD-3), will be engineered by Hoffman Electronics under $11 million USAF contract. Tall Tom will detect, record and examine transmissions over a wide range of frequencies. Data collected will be processed through computers for further analysis. Seven associate companies in the project are: Cornell Aeronautical Labs, Filtron, Lockheed Aircraft Services, Olympic Radio & Television div. of Siegler, Radiation, Sanders Associates and Stanford Research Institute.

• **An aid to electronic counter** countermeasures, utilizing a single-gun recording storage tube with search radar, has been developed by Raytheon. The system enables the operator to emit radiation for a single antenna rotation but retain the picture for up to ten minutes. Besides being a problem for enemy countermeasure receivers, the system has a navigational advantage. Instead of taking an airborne fix on constantly moving ground objects, the navigator gets a stationary ground picture related to a split second in time.

Sound Waves Weld Seams



Corrugated aluminum foil is welded to 30-in. wide aluminum extrusion by interface molecular fusion. Close-up shows transducers and acoustic horns

AN AUTOMATICALLY-CONTROLLED ultrasonic continuous seam welder which welds aluminum to aluminum and other metals has been developed by Gulton Industries.

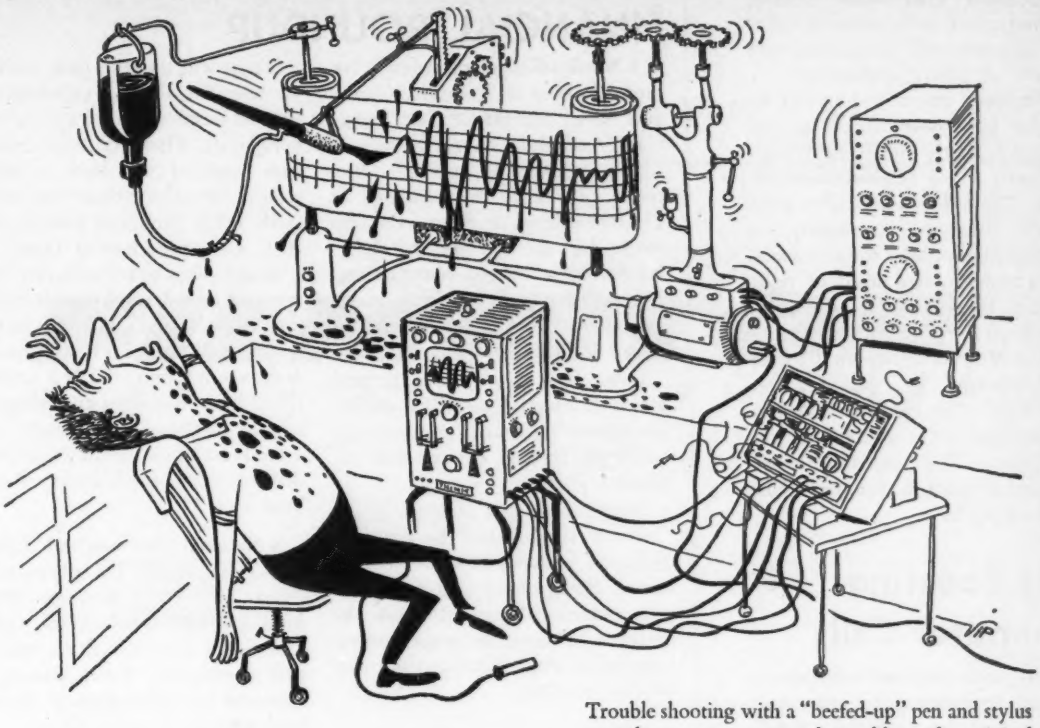
The 3-ton machine cold-welds heavy corrugated aluminum foil to both sides of a 30 inches wide semicircular extrusion needed for a classified government project. It can weld on 11 different radii.

Four seams are welded simultaneously by eight welding heads. Rate of travel, 50 inches a minute, totals 200 inches a minute. The performance is considered similar to hot welders.

The first machine cost over $100,000 to develop. Gulton expects subsequent models to cost around $15,000, including $7,000 to $8,000 for ultrasonic generators and welding heads.

A wide market is seen—not in

How to Save Man Days in Research and Testing Involving Transients—**No. 5** *of a series*



PROBLEM: Trouble Shooting

Trouble shooting with a "beefed-up" pen and stylus recorder can cause as much trouble as the original malady—thereby compounding the felony. Also, conventional recorders cannot capture high-frequency transients because of comparatively slow response.

SOLUTION: The Hughes **MEMO-SCOPE® Oscilloscope** can instantly "freeze" any number of selected traces. A storage type oscilloscope, it retains displays brilliantly *until intentionally erased*. Faithful reproduction of transients is assured always...for the electron beam has no appreciable weight, as opposed to the mass of mechanical recorder movement.

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STORAGE TUBE—5-inch diameter Memotron® Direct Display Cathode Ray Storage Tube. Writing speed for storage: 125,000 inches per second. The optional Speed Enhancement Feature multiplies writing speed approximately four times.

OPTIONAL PREAMPLIFIER EQUIPMENT—High Sensitivity, Differential Input, Type HS/6: 1 millivolt to 50 volts per division. Dual Trace Type WB/DI/11: 10 millivolts to 50 volts per division. Four independent positions may be selected for single or double channel performance and chopped or alternate sweeps.

We are sure you will want to see this "transient recorder with a memory" in action. A Hughes representative in your local area will arrange a demonstration in your company. Please write now to:

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International Airport Station, Los Angeles 45, California

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HUGHES PRODUCTS

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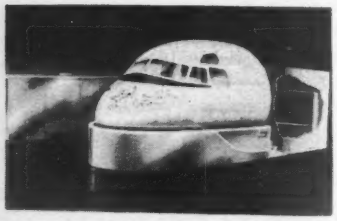
competition with other welding methods, but with manufacturers who have not been using aluminum because of joining difficulties.

Ultrasonic power is supplied by 2 2-kw generators which operate alternately as the heads move back and forth. Each head receives 500 watts. The heads consist of 4 solid barium titanate transducers, a horn which amplifies the vibrations and a welding tool fixed at right angles to the horn.

To keep the heads and workpiece acoustically tuned, barium titanate accelerometers are mounted on each horn. The feedback signal is proportional to the strength of the vibrations. The generators are designed to hunt for the maximum signal strength.

Jets Boosting Computer Calls

RECENT entry into the commercial jet field by major flight simulator manufacturers has provided a growing market for high quality electronic components. With the commercial jet age bowing in with a sonic boom, the world's airlines are leaning heavily on flight simulators to train their crews in the



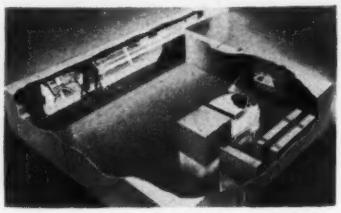
Artist's concept of Link's forthcoming Lockheed Electra simulator. Cockpit is exact replica of the actual plane

complexities of high-speed jet flight.

Basically a giant analog computer, the simulator employs thousands of vacuum tubes, precision potentiometers, servo motors and relays to realistically reproduce most of the conditions of flight in an authentic environment on the ground.

Long used by the military and the airlines to avoid the expensive and often fatal consequences of a "goof" on training flights, the commercial lines are buying this complex and costly gear to prepare for the debut of such glamor aircraft as Boeing's 707, Douglas' DC-8, Lockheed's Electra, and Convair's 880, all of which will be hurtling regularly through the air by 1960. With advanced simulator training, jet crews will be well schooled before they ever set foot in the actual plane.

Both Curtiss-Wright's Electronics Division and Link Aviation have firm orders for jet and prop-jet transport simulators from major world airlines, with first deliveries scheduled for 1958. Curtiss-Wright has been building commercial simulators since 1948, and Link moved into the area last year. An-



Link's approach to visual simulation problem. Tv camera at left reacts to pilot's manipulations

other major simulator outfit, Erco Division of ACF Industries, restricts its activities to the military, hoping to tap a potentially lucrative missile simulator market, utilizing their manned aircraft simulator experience.

Flight simulators are big busi-

FINANCIAL ROUNDUP

• **Norden-Ketay,** electronic systems designer of Stamford, Conn., and **Solar Aircraft** of San Diego, Calif., announce merger plans subject to stockholder approval. Proposed plan calls for exchange of 230,000 shares of Solar common stock for all of the 1,293,193 Norden-Ketay shares outstanding. The exchange ratio would be about one share of Solar for each 5.62 shares of Norden-Ketay.

Solar is a major designer and maker of aircraft and missile engine assemblies, airframe components, small gas turbine engines and expansion joints.

Hard-hit by loss of government contracts last fall and the resulting drain on working capital, Norden-Ketay management was forced to seek additional capital funds in order to preserve the organization, comments Paul Adams, chairman of Norden-Ketay.

• **Singer Manufacturing Corp.,** well-known sewing machine manufacturer of Elizabeth, N. J., purchases all of the common stock of **Haller, Raymond & Brown** from **Topp Industries,** electronic manufacturer of Beverly Hills, Calif. Topp received $2,075,000 for the stock of its Pennsylvania research and development division. In addition, Topp will receive $375,000 in repayment of advances to HR&B.

Topp will use the cash received to re-invest in the expansion of present business and to acquire new companies. However, new companies acquired will have a higher margin of profit than the necessarily R&D profits of HR&B, says B. F. Gira, president of Topp.

Singer plans to manufacture military and industrial electronic equipment developed by HR&B. In this way it will utilize excess capacity at plants in Conn. and N.J. created by declines in foreign and domestic sewing machine sales. Singer was a producer of electronic equipment developed by others during World War II.

• **National Aeronautical Corp.,** Fort Washington, Pa., plans to increase authorized common stock from 150,000 to 1,000,000 shares. The firm's common stock will be split five-for-one, if the increase is approved by stockholders at the annual meeting in two weeks.

• **Siegler Corp., Anaheim, Calif.,** acquires all of the stock of its subsidiary, **Sancor Corp.** of Santa Barbara, Calif. Siegler previously had a 79 percent interest in Sancor, which makes aircraft and missile ground handling equipment. Its manufacturing facilities will be relocated in a new plant, adjacent to the Siegler-owned Hufford Corp. in El Segundo, Calif.

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ness, amounting to somewhere between 40 and 50 million dollars a year. Selling price for one custom-tailored unit ranges from $750,000 to $1,500,000, with delivery from 14 to 18 months.

One airline official estimates cost-per-hour operation of a Boeing 707 is $2,700; for the same hour in a simulator—$45.

Both Curtiss-Wright and Link are in advanced stages of adding a new dimension—visual simulation—to their product.

Using closed circuit tv and a complex optical and projection system, what the pilot sees as he approaches the runway and lands his plane is effectively reproduced before his eyes. It is expected that this feature will be of immense value in familiarizing pilots with approach and landing conditions at the major airports.

System Counts Press Runs

TRANSISTORIZED counting system is being installed in the *Detroit News* printing plant to program the newspaper's press production.

It is the first use of a new RCA system which can total the output of 40 different production, processing or packaging operations. Each of 40 channels will handle 3,000 units a minute.

The *Detroit News* installation has 12 channels, one for each of 11 conveyors carrying papers from the press and a spare channel.

Switches at each conveyor imput sense folded edges of passing newspapers, generating a signal which goes to a centrally-located totalizer.

The signals are stored for a split second in electronic memories and then relayed to dividers. The dividers emit a signal for each 100 papers, moving a recording dial. When the pre-set number of copies of an edition is released, pressroom superintendent is automatically instructed to stop the presses.

Newspaper mail room supervisor sets printing order on totalizer, waits for signal run is complete

MEETINGS AHEAD

Feb. 14-15: Cleveland Electronics Conference, Fifth Annual, IRE, AIEE, ISA, CPS, Masonic Auditorium, Cleveland, Ohio.

Feb. 17-19: Military-Industrial Conf., "Strategy of the Future," Conrad Hilton Hotel, Chicago.

Feb. 20-21: Conf. on Transistor and Solid State Circuitry, PGCT, AIEE, Univ. of Penn., Phila., Pa.

Mar. 17-21: 1958 Nuclear Congress, Engineers Joint Council, AICE, and Atomfair, Atomic Industrial Forum, International Amphitheatre, Chicago.

Mar. 24-27: IRE National Convention, All Prof. Groups, Waldorf-Astoria Hotel and N.Y. Coliseum, N.Y.C.

Mar. 31-Apr. 2: Southwest District Meeting of AIEE, Mayo Hotel, Tulsa, Oklahoma.

Apr. 2-4: Conf. on Automatic Optimization, PGAC, ASME, AICHE, ISA, Univ. of Delaware, Newark, Del.

Apr. 8-10: Symposium on Electronic Waveguides, Microwave Research Institute of Brooklyn Polytechnic Inst., IRE, held at Engineering Societies Bldg., N.Y.C.

Apr. 10-12: Tenth Southwestern IRE Conference and Electronics Show, St. Anthony Hotel and Municipal Auditorium, San Antonio, Texas.

Apr. 14-16: Conf. on Automatic Techniques, IRE, ASME, Statler Hotel, Detroit, Mich.

Apr. 17-18: Second Annual Technical Meeting, Institute of Environmental Engineers, Hotel New Yorker, N.Y.C.

Apr. 18-19: Twelfth Annual Spring Tech. Conf. on Television and Transistors, Engineering Society of Cincinnati Bldg., Cincinnati.

Apr. 20-24: Scientific Apparatus Makers, 40th Annual Meeting, El Mirador Hotel, Palm Springs, California.

Apr. 21-25: Society of Motion Picture and Television Engineers, 83rd Convention, Ambassador Hotel, Los Angeles.

Apr. 22-24: 1958 Electronic Components Conf., IRE, AIEE; Theme: "Reliable Application of Component Parts," Ambassador Hotel, Los Angeles.

Apr. 24-26: National Academy of Sciences, U.S. National Comm., International Scientific Radio Union, Spring Meeting, National Bureau of Standards, Wash., D.C.

Apr. 28-May 1: Sixth Annual Semiconductor Symposium of the Electrochemical Society, Statler Hotel, N.Y.C.

Apr. 29-30: Symposium on Electronic Scanning of Antennas, AFCRC and Rome Air Devel. Command, L. G. Hanscom Field, Bedford, Mass.

FEBRUARY						
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electronics
engineering edition

FEBRUARY 14, 1958

Diode Counter Calibrates Missile Testing Camera

Speed of continuously moving film in shutterless 35-mm camera used for smear photography is calibrated in fps by frequency tachometer. Heart of meter is loaded-diode counter whose amplified output drives pen oscillograph. Though developed for specific camera, instrument may be used with any camera having similar focusing provisions

By **SAMUEL E. DORSEY** Research Department, U. S. Naval Ordnance Test Station, China Lake, California

INCREASED TEST-MISSILE velocities have created photographic instrumentation problems in the vicinity of the launching guns. As the old multiple flash technique using a background of reflective sheeting proved inadequate, a practical alternative was found in smear photography.

Knowledge of the film speed in the camera is a must in the smear technique. If the speed is too slow, the smear image is foreshortened; if the speed is excessive, the image obtained is greatly lengthened.

The principles of smear photography can be described by reference to Fig. 1. Illumination is provided by an incandescent tungsten wire on one side of the expected missile path. To the other side and

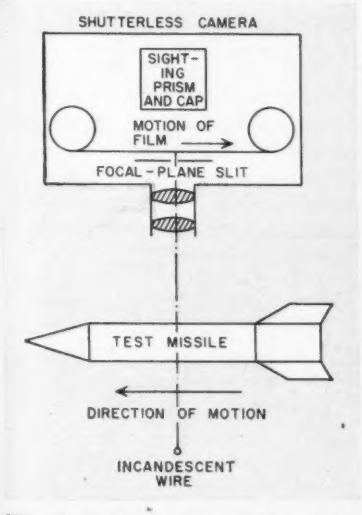
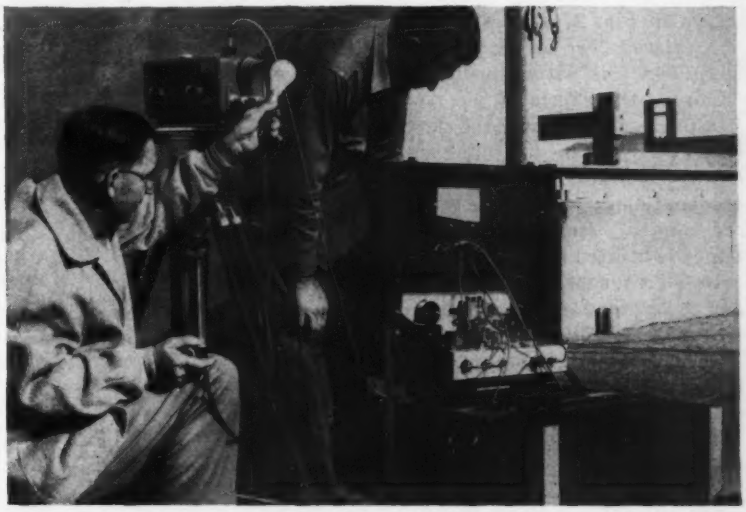


FIG. 1—Basic arrangement for smear photography of high-velocity missiles



Engineers use incandescent lamp to calibrate shutterless camera film speed before photographing actual test-missile flight

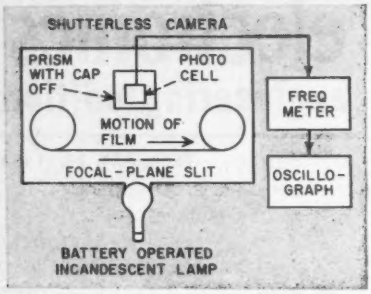


FIG. 2—Setup for camera calibration. Photocell replaces prism cap during test

on a level with the expected missile path is placed a 35-mm Warrick camera. The camera is oriented so that light from the wire passes through the focal-plane slit to the film. Behind the film are a prism and side lens intended for camera orientation. The direction of motion of the film in the camera is opposite to that of the missile. As the test object passes between the wire and the camera, its silhouette is smeared on to the film.

Camera Calibration

The Warrick camera incorporates a film-speed adjustment rheostat. However, the speed is also dependent upon the length and the resistance of the line supplying the camera motor, as well as the voltage and regulation of the power source. Therefore the film speed must be calibrated for every camera setup prior to firing.

Elements of the film speed calibrating and recording system are shown in Fig. 2. The camera lens is replaced by an incandescent lamp, which is battery-operated to eliminate the effects of a-c ripple.

A photo-cell replacing the camera prism cap picks up film speed during calibration from a specially prepared film which is run through the camera. The signal thus obtained is utilized by the photocell to drive a frequency meter whose output is recorded on the paper-strip chart in the oscillograph.

Figure 3 shows a section of the test film. It is prepared in a standard shutter-type movie camera.

This prepared film is run through the Warrick shutterless camera for film speed calibration.

The diaphragm slit in the Warrick has been opened to the width of a dark area on the test film. As the photocell drives the frequency meter, it in turn drives the oscillograph which records the frequency of the light pulsations on its chart. The reading, when divided by 16, gives the speed of the film in ft per sec. This factor is necessary as there are 16 light and dark areas per foot of calibrating film.

Tachometer

Figure 4 is the complete circuit diagram of the film speed tachometer.

The photosensitive device used is a T.I. type 700 phototransistor

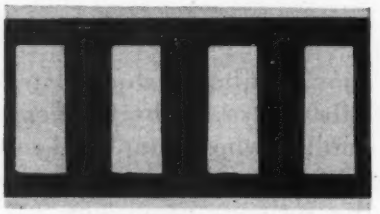


FIG. 3—Section of test film prepared in standard shutter-type camera

mounted on the end of a coaxial cable. When SET STANDARD switch S_1 is in the OPERATE position, the photocell drives the three-stage overdriven audio amplifier which converts the input signal from the photocell into square waves of the same frequency. When both SET ZERO switch S_2 and S_1 are in the OPERATE position, the output of the overdriven audio amplifier feeds the diode counter circuit.

The diode counter circuit, plus loading resistors R_1 and R_2, is the heart of the tachometer. The signal out of the overdriven amplifier is essentially a series of square waves as shown in the simplified diagram of Fig. 5A; the voltage swings in sudden jumps from the saturation value to the cutoff value in the plate circuit of the second triode in the overdriven amplifier. These square waves of voltage are represented as having a low value of e_B and a swing of e_X.

Capacitor C_S represents frequency-determining units C_{S1} to C_{S6}.

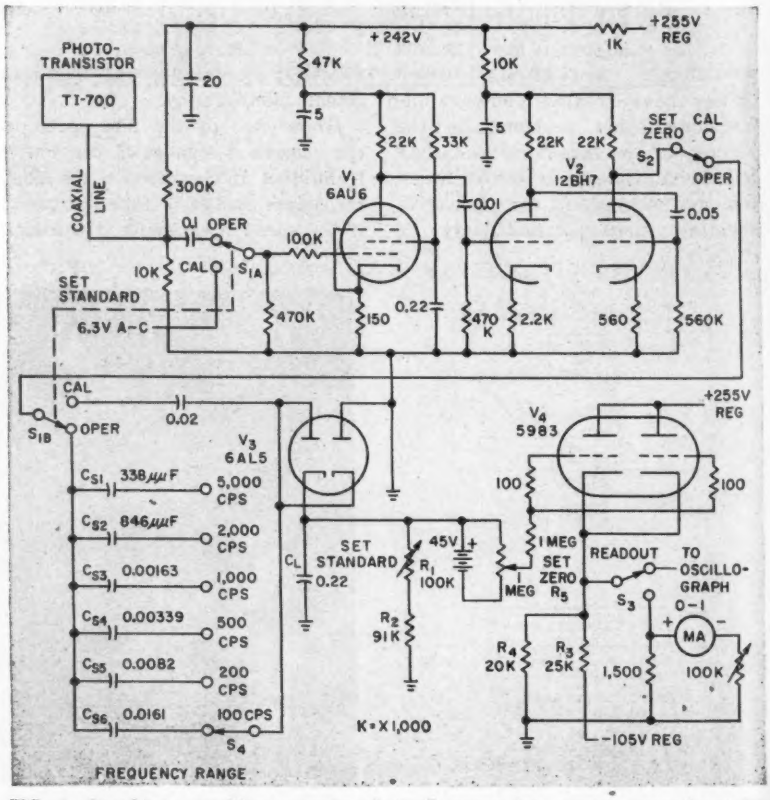


FIG. 4—Overdriven amplifier converts photocell output into square wave input for diode-counter tachometer

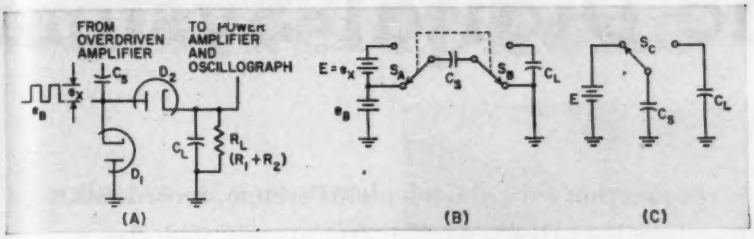


FIG. 5—Action of diode counter (A) is represented by equivalent switch circuits (B, C). Combination of R_L, C_L gives output voltage proportional to frequency

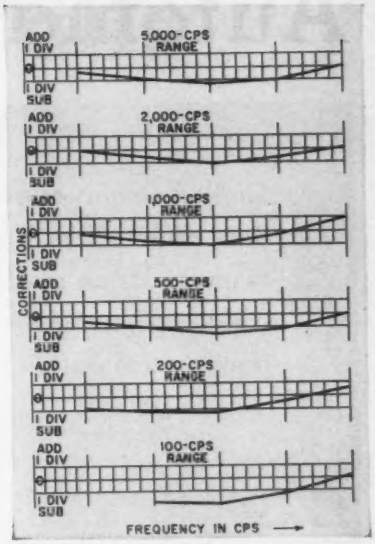


FIG. 6—Typical correction curves for different film speeds and scale factors. Speeds in ft per second are obtained by dividing ordinate values by 16

The counter diode action is represented by the equivalent switch circuit in Fig. 5B. It is assumed that each switching action is followed by a period of quiescence long enough to allow equilibrium to be attained.

Repeated actuation of S_A is equivalent to the action of the square waves of voltage out of the overdriven amplifier, alternately connecting the left-hand side of C_S to e_B and $(e_B + E)$.

The actions of the diodes in Fig. 5A can also be represented by switching. Connected to the right-hand side of C_S is S_B which is grounded when S_A is on battery e_B.

When S_A is on $(e_B + E)$, the right-hand side of C_S is connected by S_B to the top of capacitor C_L. When the voltage out of the overdriven amplifier is low, D_1 conducts to ground and D_2 is cut off. When the voltage out of the amplifier is high, D_1 is cut off and D_2 conducts into C_L. Figure 5B may be simplified to Fig. 5C without changing the counter diode action by a series of logical deductions and a mathematical treatment of the tachometer.

In Fig. 5A, resistor R_L discharges C_L at a rate proportional to its voltage, while the counter diode action tends to increase the charge on C_L at a rate proportional to the frequency of the signal from the overdriven amplifier. This combination produces a voltage roughly proportional to frequency which is fed through power amplifier V_4 in Fig. 4 to an oscillograph.

In the cathode circuit of V_4, S_3 selects either the oscillograph output or the meter on the panel of the tachometer. To balance the meter or oscillograph to zero, a negative current is supplied from the power supply through R_3 and R_4 to the cathode circuit of V_4.

Counter Calibration

The tachometer - oscillograph combination was set to zero by placing SET ZERO switch S_2 in its CALIBRATE position and adjusting SET ZERO potentiometer R_5. The motor of the oscillograph was kept running so that its pen wrote on that coarse line of the oscillograph chart chosen as the zero line. Switch S_2 was then returned to its OPERATE position.

For standardization, SET STANDARD switch S_1 was placed in its CALIBRATE position and with the oscillograph motor running, potentiometer R_1 was adjusted so the indicating pen of the oscillograph was on the coarse line chosen to represent 0.8 of full scale.

The output of an audio oscillator was then substituted for the phototransistor in the input terminals of the tachometer. With the tachometer FREQUENCY RANGE switch at each of its settings, the frequency dial of the oscillator was adjusted so that the indicating pen was directly on the coarse lines of the chart paper chosen to represent 0.2, 0.4, 0.6 and 0.8 of full scale.

From the data collected, the set of correction curves shown in Fig. 6 was prepared. The long vertical lines on this graph represent the coarse lines and the short vertical lines, the fine lines on the oscillograph record.

Figure 7 shows five camera calibration charts made with a Brush BL-202 direct-inking two-pen recorder oscillograph but utilizing only one pen.

The steep trailing edge and rounding off are characteristics of the measuring equipment. The start of the trailing edge represents the point at which the film completes its run in the camera.

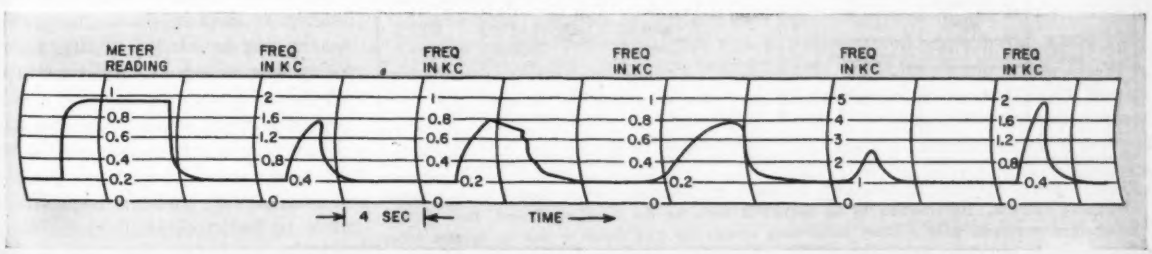


FIG. 7—Camera calibration charts. Steep trailing edge and round off are characteristics of measuring equipment

Automatic Digital System

Digital computer, used in conjunction with dial telephone system, records all data necessary to bill the subscriber. High-speed digital system includes a magnetic drum and an identification matrix equipped for 400 lines and 15 trunk-repeater adaptors. Clock track on drum provides system synchronization. System output is punched on paper tape for use by business machines

ENABLING telephone subscribers to dial both local and toll calls without the service of the phone company operator, the automatic message-registering (AMR) system described in this article identifies the subscriber, times the call and records all necessary billing data which can be processed by automatic accounting machines.

The system employs high-speed electronic digital data processing techniques. A large proportion of the system is common equipment used on a time-sharing basis by the individual telephone circuits that carry the calls requiring ticketing.

Since many telephone calls are in progress within a central office at a time, the various items of information necessary to determine the charges, such as the number dialed, calling subscriber identity, time at which conversation commences and time at which the call ends, occur at random times. The registration equipment must either accept these items of information on its common storage medium as they arrive, or store information in a temporary store associated with the speech path or trunk over which the call is being made and then transfer them all at once, and in correct order, to the common storage medium when the call is terminated. Temporary storage per trunk is used in the system. Since it is necessary to store about one hundred binary bits in each temporary store, the cost per bit must be low.

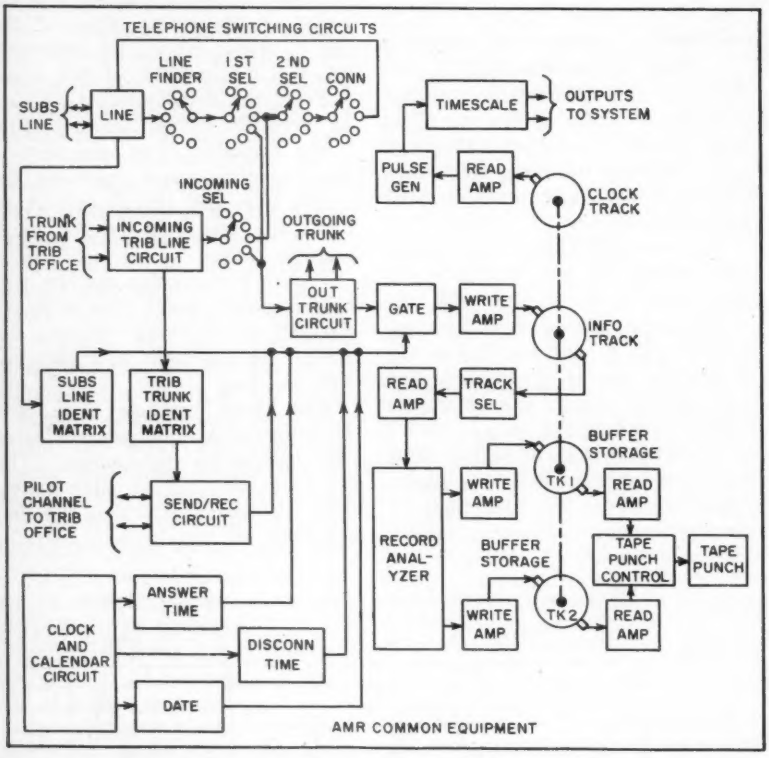


FIG. 1—Block diagram of automatic message registering system tied into telephone switching circuits. Information to be recorded such as the number dialed, time called subscriber answers, time calling subscriber hangs up and date, is fed to system from the telephone switching equipment

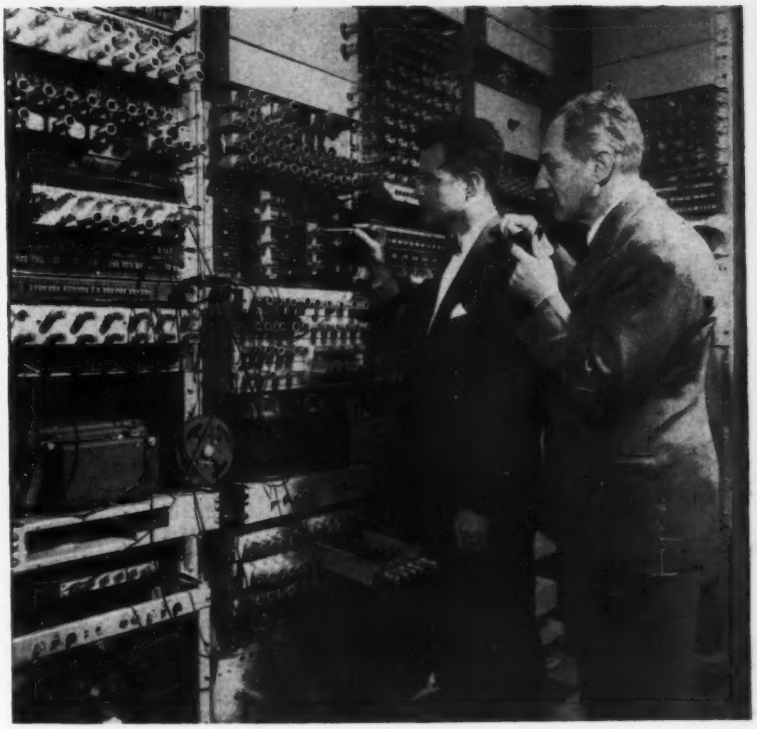
Magnetic Storage

Probably the most inexpensive storage medium and one of the easiest to use is a magnetic medium. Magnetic tape is cheaper on a per bit basis than either a magnetic drum or magnetic cores but, since this temporary storage must be on a per trunk basis, one magnetic tape transport mechanism would be necessary per trunk hence this possibility was rejected as uneconomical. With a magnetic drum, only a portion of a track needs to be allocated to a trunk and therefore one drum can be made to serve a large number of trunks. Of course, a drum would have to be supplied if there were only one trunk and this would

Bills Telephone Calls

By RAYMOND C. P. HINTON

Executive Engineer
Federal Telecommunication Laboratories
Executive Engineer



FRONT COVER—Typical installation includes an identification matrix equipped for 400 lines and 15 trunk-repeater adapters

clearly have a detrimental effect on the economy of the system. Nevertheless, it was felt that in most cases there would be a sufficiently large number of trunks for the magnetic drum to prove economical.

Synchronization

Synchronization throughout the system shown in Fig. 1 is achieved by a clock track on the drum upon which is recorded a phase-modulated, non-return-to-zero signal corresponding to a ONE for every elemental or bit position around the periphery of the drum except for the first position where a ZERO is recorded.

This clock track is read and amplified by a conventional amplifier. The last stage of the amplifier is a Schmitt trigger that generates the square wave output shown in Fig. 2. This output is differentiated and used to synchronize a free-running multivibrator that produces the master pulses used in the system.

Synchronizing an astable device was preferred to triggering a monostable device as it is inherently less liable to miss producing a pulse or to produce an extra one in the output stream of master pulses. Furthermore, when the ZERO from the clock track is read, a pulse is produced in approximately the correct position in the output stream and this stream when gated with the output of the Schmitt trigger produces one pulse per revolution of the drum.

These master pulses, 16-μsec wide, 9,000 pps, are fed to a 600-position timescale (since 600 bits are to be recorded on each track), composed of cold-cathode gas tubes of two types. One is a single element device, a number of which can be formed into a ring counter while the other is a ten element counter, which by strapping can be made into a five-way counter as shown in Fig. 3 and Fig. 4.

Time Division

Four stages of division are used in the timescale, a divide-by-four stage, a divide-by-six stage and two divide-by-five stages. The various combinations of outputs from these four stages produce 600 discrete outputs by conventional diode gating, hence any one of the 600 pulses in the master stream can be selected. This enables any one bit around the periphery of the magnetic drum to be selected for reading or writing. Furthermore, the one pulse per drum revolution obtained previously should coincide with only one output combination of these combinations. If it does not do so the timescale misstepped, hence an alarm can be given or the timescale can be reset automatically to its correct position.

Phase-modulation, non-return-to-zero recording was chosen because such a signal is a balanced waveform whatever the information to be written may be and hence a-c coupling can be used throughout.

Drum Recorder

The information to be recorded is obtained from the telephone switching equipment itself or from conventional telephone switching type circuits that work in conjunction with the switching equipment. It is gated with appropriate timescale positions so that the writing circuit may record each discrete piece of information in its correct elemental position on the drum. Four bits are used to record each

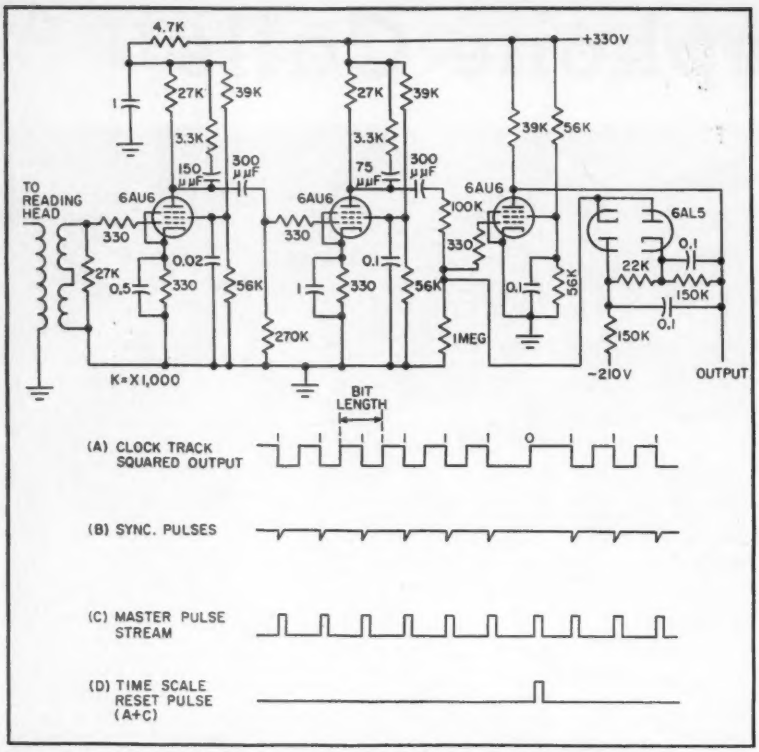


FIG. 2—Amplifier reads clock track of magnetic drum. Schmitt trigger circuit generates square wave output. Differentiated signal synchronizes master free-running mv

decimal digit and all information pertaining to calls on a particular trunk is recorded on a section of a track allocated to that trunk.

Calling Number

The calling number is obtained from a rectifier matrix in the following manner. In a single instant, a positive potential is applied to one and only one of many outgoing office trunks. This potential feeds back through the telephone switching train and arrives at and marks the line circuit of the calling subscriber.

In a large office, this is one of up to ten thousand line circuits, each one connected in a unique way to the matrix. Since only one line circuit can have this potential applied to it at any one time, a unique number corresponding to the directory number of the calling line is obtained from the matrix. This number is in the form of a d-c potential on each of four leads, each lead being one of a group of ten. It is then coded into a binary-decimal notation, mixed with appropriate timescale outputs and written on the drum in a section corresponding to the trunk at which the potential was originally applied. Once this has been done, the potential is removed from this trunk and applied to another. Thus in a similar way the identity of the subscriber calling over this second trunk is found.

Caller Identification

A small, inexpensive transistor oscillator, (Fig. 5), having a stable frequency and placed across the dial contacts of a subscriber's phone identifies the caller on a party line. Ten different types of oscillators, each having its own frequency in the voice band, are used to identify up to ten subscribers on a party line. As a subscriber dials, the dial contacts open, the line voltage appears across the oscillator and the latter then oscillates. The frequency is detected at the central office. The assigned decimal digit corresponding to this detected frequency is added to the digits determined by the line identification equipment and the result, a directory number, is recorded on the drum.

The clock and calendar circuits give dc outputs on a number of leads such that the time of day and the date appear as binary decimal numbers. These dc potentials are gated with the appropriate timescale positions to write the information on the drum. The clock and calendar circuits are composed of conventional stepping switches, that are driven by pulses from a 60-cycle synchronous motor such that a pulse occurs every 6 seconds. The switches are interconnected so the first rotates over ten positions in 1 minute, the second steps over 10 positions taking one step per rotation of the first, a third steps once for every rotation of the second and has 6 positions and the fourth steps once for every rotation of the third and has 24 positions.

The calendar switches step each time the fourth clock switch steps, for example, once per day. The switches are so interconnected as to account for the variable number of days in a month and also to automatically insert 29 days in February every four years. Furthermore, all major public holidays are automatically and specially marked, as Sunday rates apply to calls made on such holidays.

Recovering Information

Since a section of a track is permanently allocated to a trunk and within any such section specific elemental positions are allocated to particular items of information, it is necessary to remove the information recorded for one call from the drum when the call is termi-

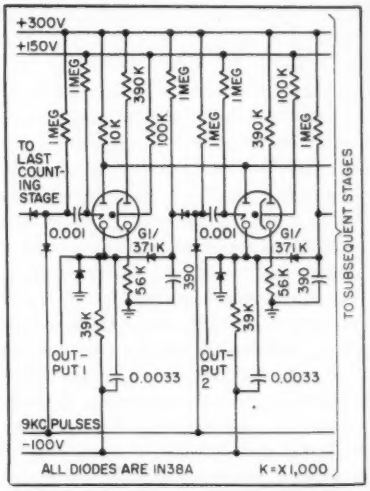


FIG. 3—Single element type counter tubes used in timescale circuit

nated. This must be done so that information for the next call made over the same trunk can be recorded.

Two methods are used. The first, shown in Fig. 1, is applicable to small telephone offices. The information is transferred as soon as a billable call (one which the called subscriber has answered) is terminated, to buffer storage tracks of the drum. This is accomplished within milliseconds of the disconnect signal from the switching equipment hence before any information for the next call can possibly come in.

Track Selection

A track selector selects each track in turn, a record analyzer examines each track thus selected and if it finds a billable call ready for extraction on the track, it transfers the information to a buffer storage track. Uncompleted calls are ignored. The buffer storage tracks are read out and the information punched into paper tape using a teletypewriter common-language code. Depending on the punch used, one or several digits may be punched per revolution of the drum.

The paper tape thus punched can be used by conventional business accounting machines to produce a bill for the subscriber.

In large offices, information is transferred from the track allocated to the trunk through the track selector and record analyzer directly to magnetic tape. In this case, since magnetic tape can be recorded at high speed, no buffer storage tracks are necessary. When magnetic tape is used it is subsequently read out at a slower speed than that at which it was recorded and the output fed directly into a conventional business machine card punch. Accounting then proceeds as before on a regular punched-card basis.

Centralizing Equipment

All the recording equipment can be located at a pivital central office. In the process of identifying a calling subscriber when the call has originated from a tributary, the positive marking potential placed on the outgoing trunk feeds back through the office to an incoming line from a tributary not to a subscriber's line circuit. The identifying potential cannot feed back to the tributary over this path so a separate signaling path is provided to relay the identity request. This is known as a pilot channel and is common to all the lines interconnecting the two offices.

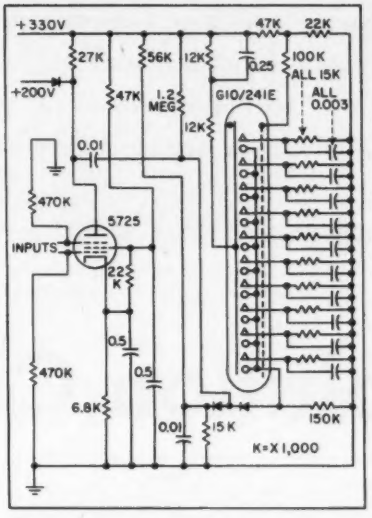


FIG. 4—Ten-element counter timescale circuit. Five-way counter uses strapping

Trunk Identity

The method of operation is such that the identifying potential at the main office determines the identity of the incoming trunk from the tributary by a matrix similar to that which determines a subscriber's line identity. This identity is signaled by two out of five multifrequency signals over the pilot channel to the tributary. This signal is decoded at the tributary and the positive identifying potential placed on the trunk, corresponding to the decoded signals, where it leaves the tributary office. From here it feeds back through the tributary office to the calling subscriber's line circuit and the identity of the calling subscriber is determined by a rectifier matrix similar to the one in the pivotal central office. This identity is signalled back over the pilot channel to the pivotal office by a succession of two out of five multifrequency signals where it is decoded and recorded on the drum.

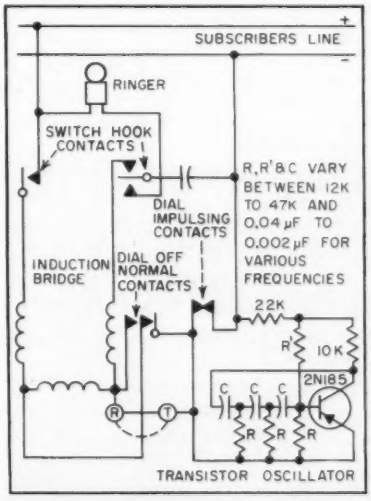


FIG. 5—Small, inexpensive transistor oscillator in parallel with subscriber's dial contacts identifies caller on party line

Coding

The recording code used is a slightly modified binary system. Since only ten combinations are required the binary code for twelve can be used wherever a seven is to be coded. This means that only one or two bits of each binary coded decimal digit can ever be a binary ONE; never none, three or four. Hence, by adding just one parity bit, each decimal digit is now represented by a two-out-of-five code which is easily checked. In all cases of signalling digits, such as between a tributary and the main office, such a checking feature is necessary and a simple way of converting from the binary code to such a code is easily achieved. Binary code is used to record on the drum as it requires less space than a two-out-of-five code.

Synchronizing

The magnetic drum allows the system to be synchronized easily, the synchronizing pulses changing if the rotation speed of the drum changes. When the output is recorded on magnetic tape a second parallel track is simultaneously recorded with synchronizing pulses, the same ones as are controlling the recording of the information. These pulses are read and used as pulses to examine the information on the tape during the reading process so any speed changes of drum or tape transport mechanism have no detrimental effect.

Optimum electronic focus of television cameras and film chains is effected by scanning bar chart and adjusting focus controls for maximum response of peaks on waveform monitor. Chart also permits rapid determination of system resolution and relative resolving power of different camera lens

By GLEN SOUTHWORTH Moscow, Idaho

Resolution Chart Aids

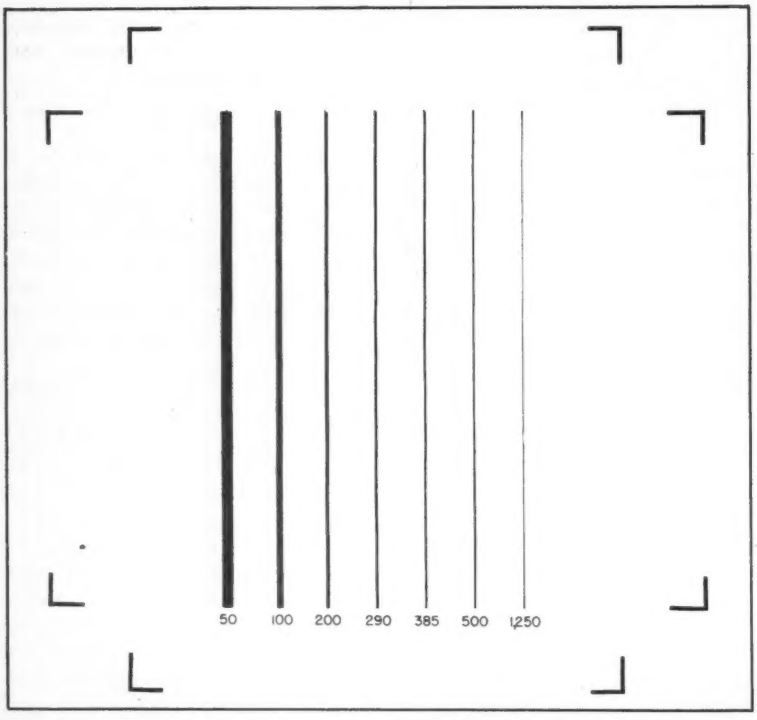


FIG. 1—Focus chart is placed at proper distance from camera so scanned area will fall within corner markings thereby producing correct signals

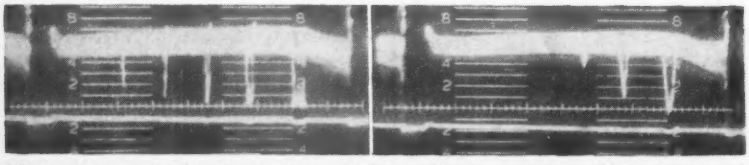


FIG. 2—In-focus (left) and out-of-focus (right) oscilloscope patterns with bars in horizontal position and oscilloscope sweep at field rate

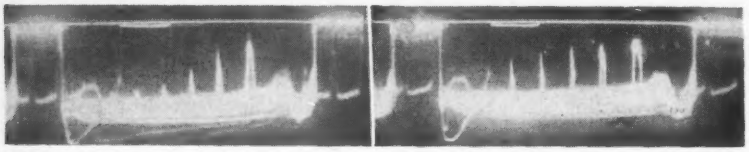


FIG. 3—In-focus (left) and out-of-focus patterns with bars vertical and oscilloscope sweep at line rate

OPTICAL AND ELECTRONIC focusing adjustments in a television system are usually dependent upon the subjective judgments of the operator.

An objective approach to the problem is offered by the chart in Fig. 1. When viewed by a television camera, it provides an oscilloscope pattern that gives a rapid indication of electrical focus adjustments; with nonmobile equipment, such as slide and film chains, the chart also aids optical focusing.

The widest black bar, corresponding to 50-line resolution response, is used as a reference and optical and electronic adjustments are made to produce maximum amplitude of the other traces.

Use of Chart

Initially, the chart is set up with the lines horizontal and the oscilloscope set to the vertical sweep rate of the system. The relatively low video frequencies give an accurate indication of the optical factors involved, as illustrated in Fig. 2. The resulting relative amplitudes may be used as a reference when the chart is placed in a vertical position, with the oscilloscope sweep frequency set to the horizontal scanning rate as in Fig. 3. Under this second condition, the oscilloscope pattern also indicates the high-frequency performance of the video system and the performance of the aperture corrector, if one is used.

This technique is based on the assumption that defocusing of a bar signal will cause the peak-energy level to diminish, at the

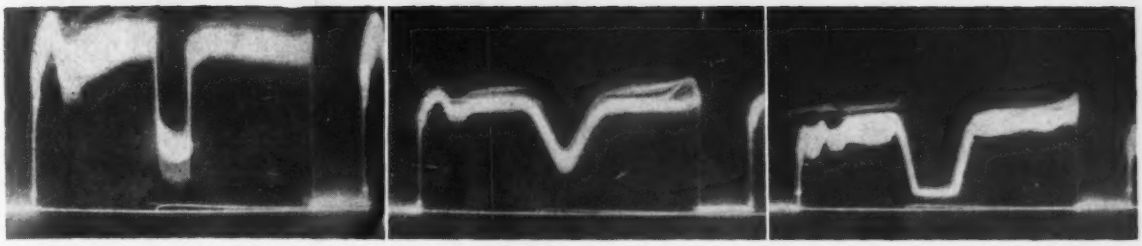


FIG. 4—Pattern of single vertical black bar when in focus (left), out of focus (center) and out of focus but expanded and clipped to simulate in-focus condition (right) as obtained using standard image-orthicon television camera

Tv Camera Focusing

same time spreading the baseline. The effect is most noticeable on thin lines where a pronounced amplitude peak may be noted when passing through the point of optimum focus.

This rule of thumb does not hold completely true for some types of astigmatism, for example image twinning, but for most purposes seems to provide a sensitive and reasonably objective means of determining optimum focus of the camera.

Performance Evaluation

The focus chart provides a simple and rapid indication of overall system performance, as well as the relative resolving ability of different camera tubes. To accomplish this, the focus chart dimensions were chosen so the width of the lines correspond to 50, 100, 200, 290, 385, 500 and 1,250-line characteristics.

Resolution may be recorded in percentage of response at 385 and 500 lines, or higher if desired, and kept for future reference as an indication of possible system deterioration.

Response in older image-orthicon tubes seems to begin to drop off above 200 lines and the amplitude of the 600-line trace may be as low as 10 percent of the 50-line response. This drop in response seems to be the result of the electron optics of the tube, as it occurs with the television test chart situated in both vertical and horizontal positions.

Construction

The line widths were calculated by dividing the vertical dimension of the chart by the number of lines of resolution desired.

A fine trace, corresponding to a approximately 1,250-line response, is included on the chart as an aid to critical focusing. Though this might appear to be outside of the capabilities of the normal system, a single line of this sort will frequently be reproduced, though broadened and greatly reduced in amplitude.

The chart is also useful in detecting and measuring leading or lagging vertical overshoot due to camera misalignment.

Simulating Sharpness

Apparent sharpness may sometimes be increased by clipping or other forms of amplitude compression. This is illustrated by the series of waveforms in Fig. 4 related to the reproduction of a single black bar.

The photographs of Fig. 5 are shown as examples of some of the differences in apparent sharpness that may be produced by various methods of television camera operation.

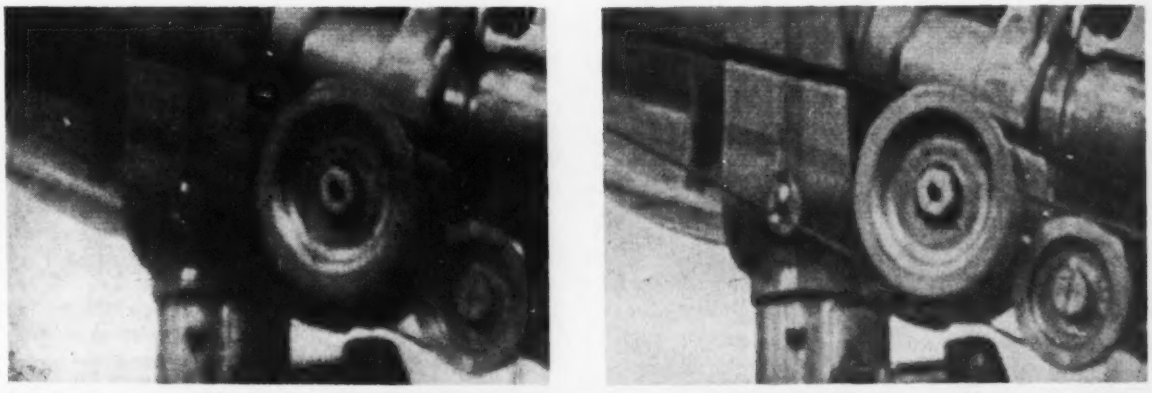


FIG. 5—Image obtained from image-orthicon television camera set up to render normal grey response is improved by tonal compression obtained by opening lens aperature and reducing target voltage

Intruder Alarm Uses

Transistorized burglar alarm has electronically modulated infrared light source and synchronous phase-sensitive demodulator pickup unit. Pulsed light technique overcomes adverse effects of continuous or varying ambient light conditions. Alarm also sounds if power supply or interconnecting lines are tampered with.

By **S. BAGNO and J. FASAL** Walter Kidde & Company, Inc., Belleville, N. J.

INTRUDER DETECTION systems must be virtually foolproof, even under the most difficult conditions of operation, and they must also provide safeguards against false alarms or being rendered inoperative by intruders. Furthermore, the system must not respond to a variation of the light intensity and should not be affected, within practical limits, by such climatic conditions as fog, rain or snow.

Because intruders have developed increasingly more ingenious methods of defeating conventional alarm systems, a phase-sensitive system has been developed. An invisible infrared light beam keeps introduers unaware of its exact location. Any tampering with the power supply or any other interruption of lines produces an alarm.

The basic principles of the photoelectric alarm system are illustrated in the block diagram, Fig. 1. A 55-cps transistorized power oscillator powers and modulates the light source and supplies a reference signal to the phase-detector stage of the receiver. Any deviation between the reference-voltage phase and the phase of the modulated light beam deenergizes the relay in the output circuit of the phase detector.

Modulation

The oscillator frequency is made slightly different from the line frequency to eliminate the possibility of synchronization with the 60-cps line which would enable an intruder to paralyze the system by directing a 60-cps stroboscope into the housing of the phototransistor.

The beam modulation frequency is directly related to the percentage of light modulation. The tungsten-lamp filament reaches its maximum temperature when the collector current of the oscillator transistor goes through its peak value and cools off to its minimum value when its collector current goes through zero. If the time interval between maximum and minimum is small, (frequency is high) the filament does not have time to cool off so much as when the frequency is low. This means that the light modulation with high frequency will be less than with low frequency.

For some applications, it may be necessary to increase the oscillator frequency to detect small and fast-

Alarm system operation is checked with perforated sheet between receiver and transmitter units

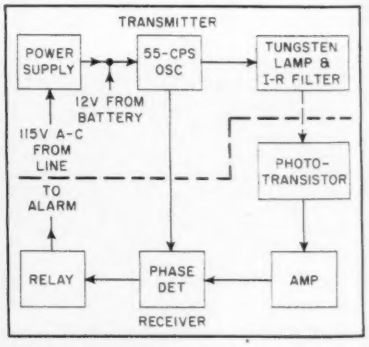


FIG. 1—Basic elements of transmitter and receiver units that make up alarm

Phase-Sensitive Detector

moving objects, but the price is always the loss of sensitivity, as a result of a lower percentage of light modulation.

Due to the optical characteristics of the phototransistor and the type of glass used, only the portion of the radiated modulation falling above 2 microns is detected, as illustrated in Fig. 2. Since that portion of the spectrum shorter than 2 microns includes most of the energy radiated by high-temperature light and only the portion of the low-temperature light most sensitive to temperature modulations, the phototransistor response indicates that the received modulation percentage is relatively constant and independent of the average filament temperature over a wide range.

A series-emitter resistance can stabilize a phototransistor against ambient variations in collector current.

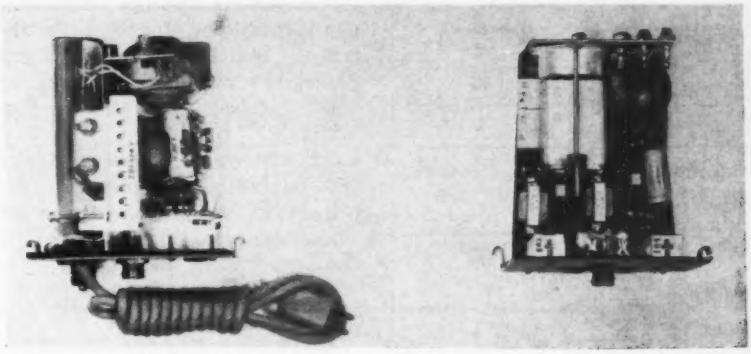
This effect can be used to make the steady-state d-c response of the phototransistor and its a-c response independent of each other. Thus, for steady-state light, the phototransistor has the low sensitivity of a photodiode, whereas for modulated light it can approach the full sensitivity of a phototransistor —a gain of more than 40 db over the d-c steady-state light response. In that way the phototransistor can operate in bright ambient light without becoming saturated and insensitive to light modulations.

Phase Detection

The basic schematic of the phase detector is shown in Fig. 3 in simplified form.

The amplified signal from the phototransistor drives the base of the phase detector (Fig. 4B).

The emitter-collector voltage of the phase detector is supplied from the 55-cps transistor oscillator through an unfiltered bridge rectifier and through a d-c relay located in the a-c branch of the rectifier bridge. The emitter-collector voltage is therefore a full-wave rectified signal (Fig. 4D) derived from the reference signal in phase with the phototransistor signal (Fig. 4C). The phase shift between phototransistor and reference signals that results from the thermal lag of the filament is corrected in the amplifier.



Unhoused transmitter and receiver chassis are shown at left and right respectively

The resultant collector current (Fig. 4E) of the phase detector depends on the instantaneous voltages on the base and collector and can be considered as the modulation product of both. This current must always be in phase with its driving voltage. Therefore, on the d-c side of the rectifier, where the adjacent half waves are in the same direction, this current will be in the same direction although modified in amplitude by the signal on the base of the transistor.

Similarly, on the a-c side of the rectifier, this current although equally modified in amplitude by the transistor, will have its adjacent half waves alternating in direction in response to the driving alternating potential and be in phase with it (Fig. 4F). This current is therefore a nonsymmetrical alternating current that contains a d-c component by which the relay is energized. The a-c component of the current is bypassed.

There are several cases to consider in the behavior of the phase detector under varying operating conditions.

Suppose first that the phase between the phototransistor signal and reference voltage had been reversed (Fig. 4I). This is caused by a reversed primary or secondary winding of one of the coupling transformers.

The considerations leading to the waveform of the collector current and the current through the a-c circuits and through the relay are the same as before. The only difference is that the sequence of the smaller and larger amplitudes of the wave is now reversed. Therefore, the d-c component in the relay circuit or the relay voltage itself has to change its sign as shown in Fig. 4N.

Other Phase Conditions

When no light or nonmodulated light reaches the phototransistor, as shown in Fig. 4O, the phototransistor signal is zero, while the bias reference and full-wave rectified reference signals are the same as before. However, the resultant collector signal will be proportional only to the rectified reference signal because the base signal is the constant bias voltage.

The current through the a-c circuit will be a sinusoidal current without any d-c component so, in this case, the relay is deenergized and drops out.

Another interesting and important condition exists when there is a phase shift of 90 deg between the photo signal and reference signal, as shown in Fig. 4V.

To obtain the resultant collector signal consider adjacent quarter-

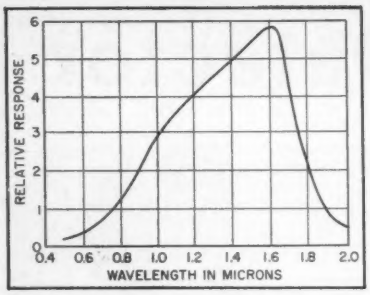


FIG. 2—Typical response of phototransistor to various wave lengths

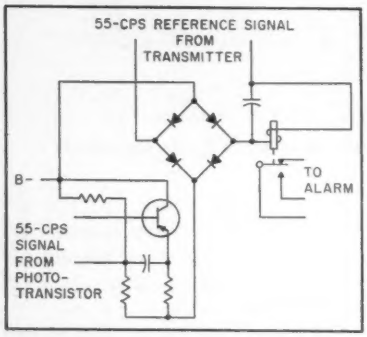


FIG. 3—Simplified representation of basic phase-detector circuit

waves; the first quarter-wave is equal to the fourth, although the mirror image of it. Similarly, the second and third quarter-waves are equal mirror images of each other.

Therefore, the sum of the first and second quarter-waves are equal to the sum of the third and fourth quarter-waves. That they are mirror images of each other does not alter the fact that their areas are equal. Thus, on the a-c side of the rectifier, the positive half-waves will exactly cancel out negative half-waves and give a zero d-c component. The relay is deenergized and the alarm sounds.

Other Cases

For other cases where the phase shift lies between 0 and 90 or 90 and 180 deg, a d-c component will exist in the relay circuit that becomes smaller as the phase shift approaches 90 deg and larger as the phase shift approaches 0 or 180 deg.

From the previous case, it may be seen how the system will behave when the frequencies of the phototransistor signal and reference voltage are slightly different. The two frequencies behave as if the phase between them were continuously changed. Therefore, within periodically repeating time intervals, the two waves will be in phase, 90 deg or 180 deg out of phase, passing through all possible phase conditions. Consequently, the relay is periodically energized and denergized and thus triggers an alarm during the unenergized intervals.

As the same detecting device acts on both half-waves that are being compared, any change in the detecting device acts symmetrically and cannot affect the balance.

Phototransistor Properties

There are some properties of the phototransistor that affect the reliability of the whole system.

The collector current of an uncompensated germanium transistor will double for each 8C temperature rise. This can be somewhat obviated with proper temperature stabilization.

Furthermore, a phototransistor, changes continuously and asymptotically, the phase between light modulation and photocurrent. Under unfavorable conditions, it may slowly reach a phase shift of more than 15 deg during a day of operation. When the phototransistor is disconnected from its power supply the phase immediately returns to its original position.

This phase shift becomes more important the higher the emitter-collector voltage. The effect is based on the formation of capacitance bounded channels, which are nonuniform diffusion p and n regions penetrating from the surface of the semiconductor into the base. These channels have a certain capacity to the barriers of the semiconductor which increases with time when the static charge builds up under the action of the internal d-c field.

Since the capacitance of a p-n junction is a function of voltage and the voltage in turn is a function of the charge that has been built up through resistance with time, the overall capacitance becomes de-

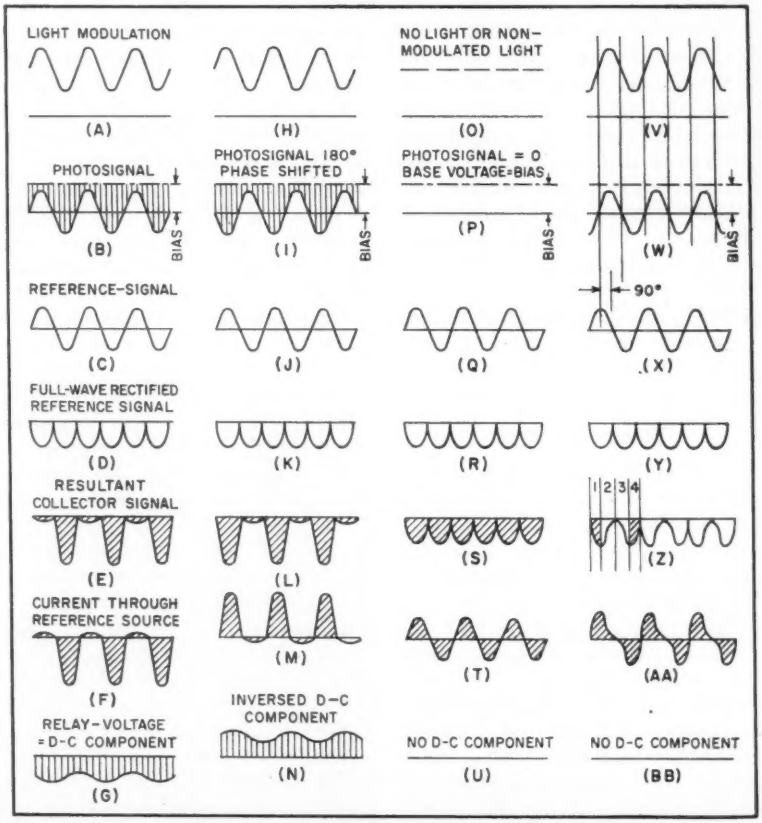


FIG. 4—Typical waveforms in system for different operating conditions

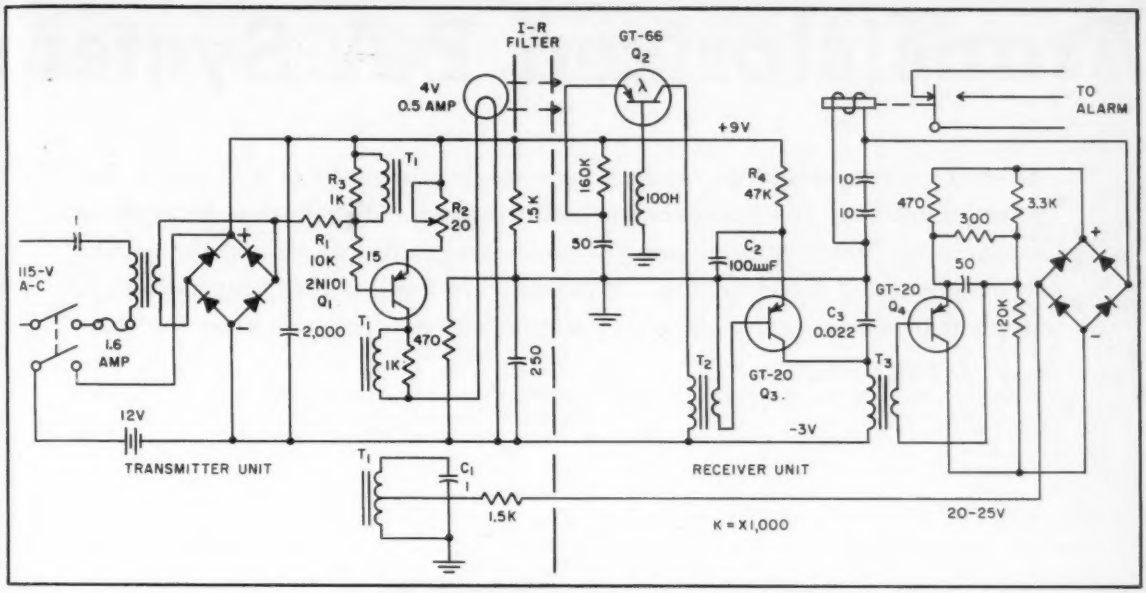


FIG. 5—Complete system normally operates from 115-v a-c power source with storage battery floating; battery takes over load if line supply fails. Capacitor C_1 tunes winding of T_1 to 55 cps, the oscillator frequency

pendent on voltage and time. The entire system corresponds to a rather complicated R-C network in which the capacitance is a function of time and voltage. That time varying network is the origin of the variable phase shift.

Although the network presents large phase shifts to low frequencies (55 cps) the response is hardly affected at higher frequencies.

The phase drift between phototransistor signal and reference voltage must be eliminated as much as possible. By reducing the emitter-collector voltage, the phase shift can be reduced to a nonmeasurable amount. This also reduces the noise level.

Light Dispersion

An important consideration is the dispersion of the light beam energy so a large portion of the light is lost and does not reach the receiver. The narrower the beam angle the more serious such a situation can become.

In general, the loss in light varies inversely as the area that the transmitter beam would tend to cover in the plane of the receiver. For a given distance between transmitter and receiver, the area of the optical image of the light source would increase inversely as the square of the *f*-number of the optical system of the transmitter. Thus, going from an optical speed of *f*2.5 to a speed of *f*0.25, which can be obtained for a condenser system, decreases the sensitivity to lens fogging 100 to 1. For this reason, the highest speed optical system was used; a sealed beam lamp with a parabolic reflector.

Circuit

The schematic of the photoelectric alarm system is shown in Fig. 5.

The primary of the power transformer, which is a saturable type, forms a voltage regulator, in conjunction with the 1-μf capacitor, that maintains a constant d-c supply of approximately 12 v, independent of line voltage variations of + 20 percent but not independent of load.

Where standby power is required, a 12-v battery is connected to the projector unit. In normal operation the battery is trickle charged by the power supply. In the event of a-c power failure, the battery automatically assumes the load.

Resistor R_1 provides proper base current for oscillator Q_1; R_2 controls degeneration to vary the a-c voltage on the lamp. The winding of T_1 that is in series with the lamp and collector of Q_1 provides regenerative feedback to the winding that is connected to the base and emitter; R_3 provides loading to prevent parasitic oscillations.

Capacitor C_1 and its associated winding tune the oscillator to approximately 55 cps. The center tap of this winding supplies an a-c voltage of 20 to 25 v which is relatively independent of lamp intensity setting.

Modulated light falling on the photosensitive junction of Q_2 modulates its collector current. This 55-cycle current is coupled through T_2 to amplifier Q_3, the emitter of which is biased through decoupling network R_4, C_2.

Since the thermal time constant of the lamp produces an inductive phase lag in the transmission of the modulated light, it is necessary to correct the phase of the amplified signal with phasing capacitor C_3. The corrected signal is coupled through T_3 to the phase-detector stage.

The phase-detector output results in a filtered d-c across the relay, holding it in the energized position.

The normal sensitivity of the system extends to 700 feet, with a four-to-one safety factor for dust and misalignment factors that affect operation at that distance.

Transistorized P-A System

Aircraft passenger-address system uses single preamplifier and up to five power amplifiers and speakers for uniform audio distribution throughout seating area. Differences in ambient noise level in the air and on the ground are compensated by switching. Transistors are used as matching devices to supplant transformers at input and output, and as electronic filter for noise

By J. M. TEWKSBURY
Research Engineer, Bendix Radio Division, Bendix Aviation Corporation, Baltimore, Maryland

SUCCESSFUL DESIGN of aircraft passenger address systems requires flexibility enough to compensate for differences in noise level from one type of aircraft to another, for the changing levels of ambient noise encountered in various positions in any given aircraft, and for differences in the noise patterns aloft and on the ground. Fig. 1 shows how the noise curve changes from the nose to the tail of a typical aircraft. Improved aircraft design has reduced ambient noise levels to a point where the use of the passenger address system for radio programs, frequent routine communications from crew to passengers, tape recordings and other forms of entertainment has become practical.

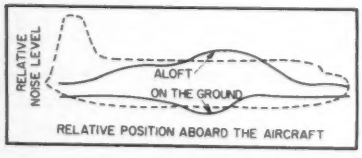


FIG. 1—Noise levels aboard aircraft

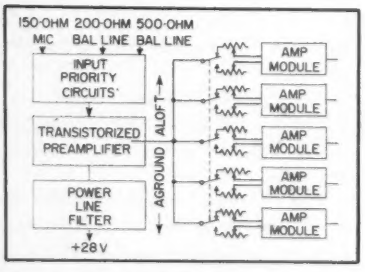


FIG. 2—Functional diagram of 5-station passenger-address system for airliners

Transistor Modules

The amplifier to be described is the first-known completely transistorized aircraft p-a system amplifier available to the aviation industry. The key to its flexibility and efficiency is the use of modular construction.

In a passenger address system using this amplifier the seating area is divided into from one to five audio zones, depending on the type of craft. A plug-in amplifier module producing eight watts of audio power is provided for each zone. Individual potentiometers for each amplifier provide independent control of the sound level. To compensate for the difference in audio levels on the ground as opposed to in the air, an air-ground output switch is provided which acts on all amplifiers simultaneously.

The block diagram of Fig. 2 shows the control setup which permits the selective use of audio power. Three input circuits are available which can be adapted to use with carbon microphones, dynamic microphones and tape machines. Order of switching priority is pilot-to-passengers, then stewardess-to-passengers, then the passenger-entertainment circuit.

Transformer Elimination

In push-pull transformer-coupled output circuits there is an auto-transformer action which places a voltage equal to double the supply potential on the transistors. Hence with a 28-v supply there would be 56 v on the transistors at maximum output. This would necessitate the use of transistors with a high breakdown voltage. But transistors of this type are relatively expensive and their current linearity is generally not satisfactory for this application.

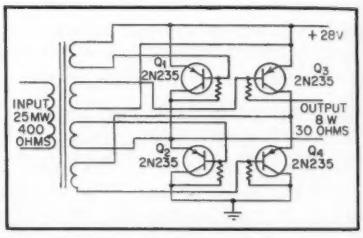


FIG. 3—Power amplifier module schematic

Circuit Details

These difficulties are eliminated by the use of the bridge circuit shown in Fig. 3. Transistors Q_1 and Q_4 are conductive for half a cycle while Q_2 and Q_3 supply the other half-cycle to the load. The maximum peak voltage applied to the load is about 26 v, while the peak current reaches 0.93 amp at 8 w output. Although the 2N235 transistor is capable of 26-w peak output in class B, the 1,200-ohm bias resistors bring about conservative operation in class AB.

One of the inputs required is 200 ohms push-pull at −50 dbm. The

Adjusts to Aircraft Noise

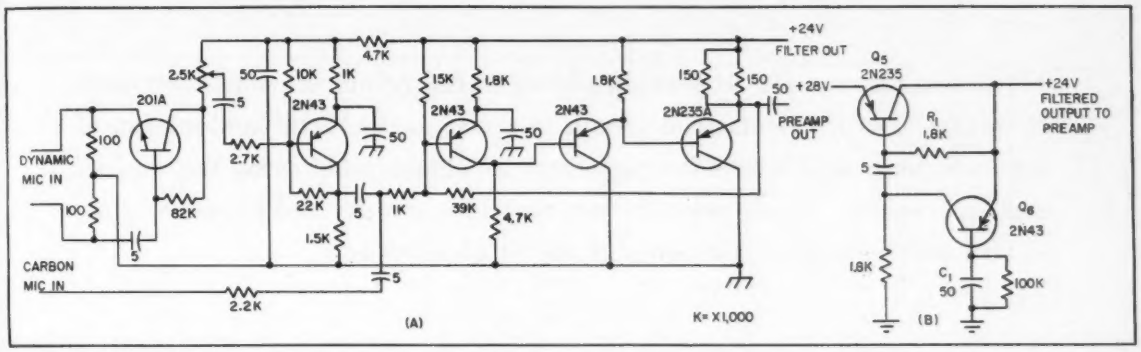


FIG. 4—Schematic of system preamplifer (A). First transistor is coupling device which eliminates push-pull to single-ended transformer. At (B) is electronic filter for d-c line

conventional way to connect such an input is to employ a push-pull to single-ended transformer. An *npn* transistor, however, connected as shown in Fig. 4A is completely equivalent, and this circuit accomplishes the input function with a saving in weight and volume.

Noise Filtering

Another problem to be overcome in the development of p-a amplifiers involves the prevalence of noise components on the 28-v lines of virtually all commercial aircraft. This may be as high as two volts rms on the 28-v bus. This noise must be filtered to prevent it from appearing in the preamplifier stages.

This filtering is accomplished by the special electronic filter shown in the schematic diagram of Fig. 4B.

Referring to the diagram, R_1 biases Q_5 so that, with the current normally present in the circuit, there is a 24-v output and C_1 charges up to approximately 24 v. Any change in the voltage at the output side of the filter is amplified by Q_6 and applied to Q_5 in such a way as to oppose the change. Experimental results indicate that C_1 is amplified 1,000 times in value, thus having an apparent capacity of 50,000 μf.

It is not at all necessary to filter the A+ supply to the bridge amplifiers because the collector impedance is extremely high. Consequently little a-c noise is transferred to the low-impedance bridge output load.

The collector current in the amplifier is essentially independent of collector voltage. The base current is produced by the signal input voltage. The current which flows in the collector circuit is many times greater than the base current once saturation has been reached. Thus the output load is almost completely isolated from any a-c components on the d-c input line.

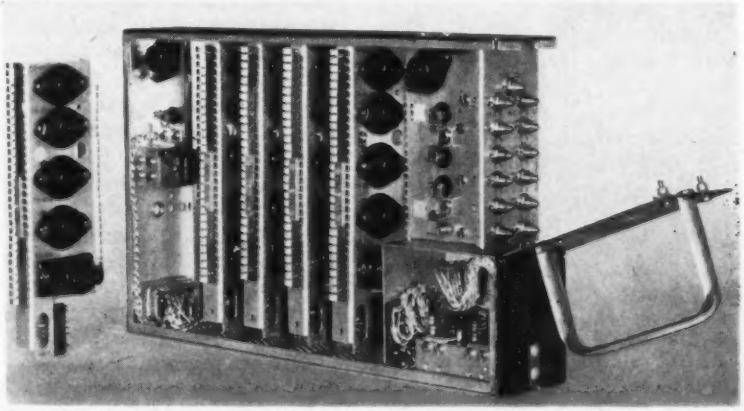
Heat Dissipation

Perhaps the most serious limiting factor in the use of transistors in this application is their inability to withstand high temperatures. A study of the heat-dissipation problem resulted in the establishment of certain basic data.

The data shows that the average power dissipated can be calculated by integration and the equation reduced to $P_{av} = 1/2\pi\ [E\ (2P/Z]^{1/2} - (\pi P/2)]$, where E is the supply voltage, P is the power output of the bridge and Z is the load impedance.

With a supply of 28 v and a load impedance of 30 ohms it then becomes a simple matter to plot the dissipation of each transistor against the power output of the bridge.

This amplifier is the result of growing demands for lighter, smaller, less complex and more reliable airborne units. It has been made possible largely by the use of transistors and the application of new design techniques which transistors permit.



Modular 5-station amplifier. Two sets of potentiometers, one for air and one for ground, permit audio level balance

Print Timer Controls

Electronic timer, used to develop photographic prints of consistant quality makes use of phantastron circuit to arrive at the right combination of exposure time and color filter necessary to obtain and repeat the desired exposure values. Timer controls two variables, density and exposure time, to faithfully reproduce the tones of the original scene.

By **JAMES D. WEIR** Assistant Professor of Engineering Research, Ordnance Research Laboratory, Pennsylvania State University, University Park, Pa.

WHEN DEVELOPING photographic prints, both density and contrast must be controlled to obtain a print that faithfully reproduces the tonal variations of the original scene. Density is proportional to the exposure time and the light impinging upon the emulsion. Contrast is determined primarily by the characteristics of the emulsion.

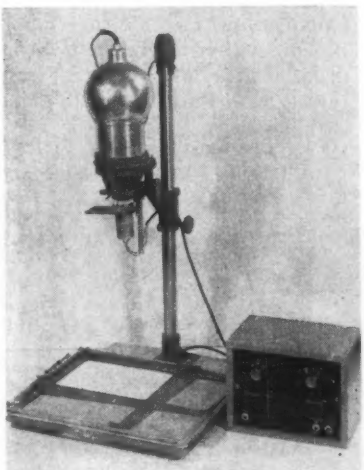
Contrast papers coated with emulsions sensitive to the color of the exposing light, provide the dark-room operator with a simple means of controlling contrast. These papers are coated with two emulsions, one for low contrast, the other for high. The low-contrast emulsion is sensitive to yellow light, the high to blue light. The right contrast is obtained by exposing the print through one of ten color filters that control the relative proportion of yellow and blue light. Even an experienced photographer must exercise considerable skill to arrive at just the right combination of filter and exposure time for a perfect print.

Control by Filters

The process can be performed by using only the two filters at the opposite ends of the range (yellow No. 1 for low contrast; blue No. 10 for high contrast) and controlling the relative exposure time. Even with this method, there is still much room for operator error.

Operator error is reduced with the electronic timer. Any exposure time between 6 and 60 seconds is set on one dial and any contrast provided by Varigam or similar papers is set on another dial. Exposure time is calibrated accurately and will not vary more than 2 per cent of the set value.

The phantastron control circuit,



Print timer is shown beside the enlarger with the filter-switching motor mounted in place of the red filter normally supplied with the enlarger. The two color filters are mounted on an aluminum plate attached to the motor shaft. Shock mounts prevent jarring of enlarger when switching filters to change contrast

used extensively in radar and fire-control equipment, is shown in Fig. 1. In most applications, plate and grid voltages are clamped to their respective points on the voltage divider by diodes. However, relay contacts are used with the controller to reduce the charge time on C_1 and permit immediate recycling with no loss of accuracy.

Timing Cycle

The timing cycle is initiated by operating K_1 to remove the clamping from plate and grid. When the clamping is removed, the plate voltage immediately drops approximately six volts. This drop coupled through C_1 forces the grid voltage down to a value that reduces the plate current to the few microamperes necessary to establish the plate-to-grid voltage at the initial value e_1.

From this time to the end of the cycle, the circuit acts as a Miller integrator. An almost constant capacitor-discharge current is maintained and if properly designed, the plate voltage will run down linearly with time within a fraction of one percent.

During plate-voltage run down, the cathode voltage rises a slight amount at a constant rate. Since the plate current is controlled by the suppressor grid, it is eventually cut off as the plate voltage de-

Density And Contrast

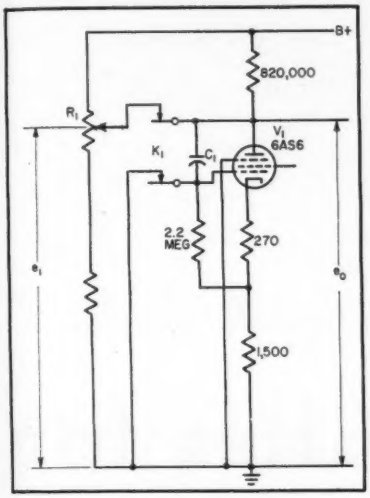


FIG. 1—Phantastron circuit used in radar and fire-control equipment

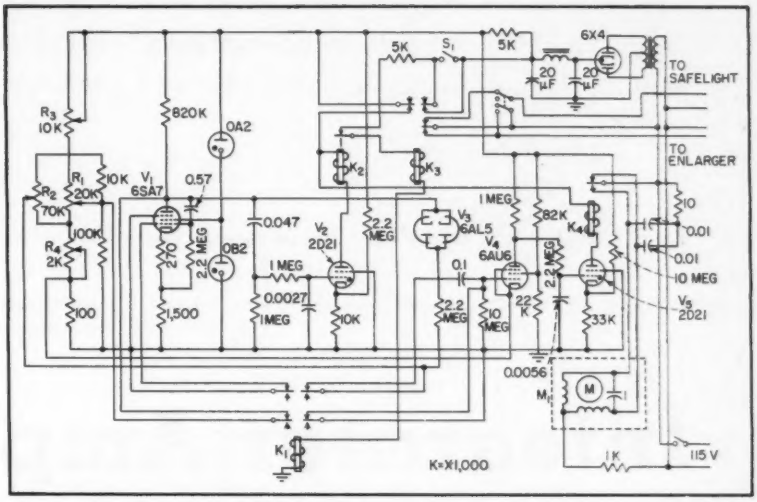


FIG. 2—Electronic timer circuit shows R_1 used to set the exposure time and R_2 to regulate any contrast from high to low

creases and the cathode voltage increases. At this time, the plate voltage suddenly starts to rise and causes the grid and cathode voltages to rise which further increases plate-current cut-off. With the circuit constants shown, the plate-voltage run down is linear with time over the entire cycle.

Circuitry

To operate the timing circuit, Fig. 2, pushbutton switch S_1 operates relays K_1 and K_2. Contacts on K_2 turn on the enlarger, supply power to the thyratron plates and lock K_2 and K_1 closed. When K_1 operates, the plate-voltage run down on V_1 begins. At the end of the cycle, the sharp rise in plate voltage fires thyratron V_2 to operate relay K_3. This action interrupts current flow through K_1 and K_2 to reestablish the initial conditions.

Potentiometer R_3, diode V_3, d-c amplifier V_4, thyratron V_5, relay K_4, and induction motor M_1 constitute the contrast-control section. Potentiometer R_2 is set to establish the plates of V_3 to any percentage of the plate run-down voltage. Since the cathodes of V_3 are positive with respect to the plates, no current flows through V_3 until the plate voltage of V_1 drops to a value equal to that set on R_2. When the voltage does drop to this value, a voltage appears at the grid of V_4, which, when amplified at the plate, fires V_5 to close relay K_4. When K_4 closes, M_1, reverses direction.

The small induction motor is mounted on the enlarger so that the filters attached to its shaft rotate close to the enlarger lens. The motor does not run except when switching filters. When K_4 is open M_1 turns to a stop that positions the yellow No. 1 filter under the lens and, when K_4 is closed, a stop positions the blue No. 10 filter under the lens. Switching time is a fraction of a second. Relay K_1 shorts V_3 plate and V_4 grid resistors for rapid recycling.

Calibration

Potentiometers R_1 and R_4 permit the timing cycle to be precisely adjusted at the low and high ends of the range: R_1 to set the maximum time and R_4 to set the minimum time. Since there is some interaction between these adjustments, calibration must be repeated several times to insure accuracy. With several trials, the accuracy at each end can be set to within one percent. Mid-range accuracy depends on the linearity of R_1.

Contrast Setting

With the circuit constants shown, any time from 6 to 60 seconds can be set by R_1 and any contrast from low to high can be set by R_2.

The density of filter No. 10 is normally greater than that of No. 1. Twice the exposure time is required with the No. 10 filter than with the No. 1 to obtain the same reflection density in the print. If this condition were to exist with the controller, the printing time would have to be varied with different filter settings.

A simple solution to this problem is to cement a neutral-density filter (one with approximately 50 percent transmission) over the No. 1 filter. With this arrangement, no printing time compensation is necessary with different contrast settings.

The author thanks C. R. Smitley, W. J. Leiss, C. K. Arnold and R. Swope for their assistance and C. W. Young for photography.

Electronic integrator-amplifier simplifies and speeds grading and matching of magnetic cores. Miller-type integrator measures instantaneous and peak flux in cores at excitation frequencies of 60, 400 and 1,600 cps. Design approaches ideal response throughout 480-kc bandwidth and provides closed loop gain of two at fundamental excitation frequencies. Amplifier increases output to required measurement level and minimizes phase shift

By **CHARLES E. GOODELL** Hughes Aircraft Company, Culver City, Calif.

Integrator-Amplifier for

FLUX-CURRENT LOOP characteristics of materials used in magnetic cores determine the abliity of a core to function adequately in amplifying or switching applications, or as a simple magnetic element. Therefore, by measuring various magnetic properties of the core material beforehand, the user can assure himself that the core selected meets his specific requirements.

The grading and matching of cores and core materials can be accomplished more easily and quickly using the integrator-amplifier described here.

The integrator is of the Miller type and has been designed specifically for measurement of magnetic core characteristics at excitation frequencies of 60, 400 and 1,600 cps. Two important magnetic properties of cores measured by the integrator are magnitude of the instantaneous flux wave developed as a function of excitation voltage and peak flux within the core.

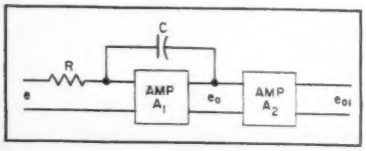


FIG. 1—Block diagram of integrator

Since the time integral of voltage is a measure of the instantaneous flux existing in the core and since the peak signal from the integrator is proportional to the peak flux, measurement appears simple. The requirements placed upon the integrator, however, are severe. For this reason it is necessary, in practice, to compromise between accuracy of measurement and complexity of design.

Initial Assumptions

To solve the design problem, it is necessary to make certain initial assumptions. As finally conceived, the integrator design assumes: (1) the core is excited by a sine current, (2) the crest factor of the induced voltage wave will not exceed a factor of 50, (3) the minimum rms induced signal, for the smallest core and least number of turns on the pickup coil, will always exceed the equivalent rms input noise of the integrator by a factor of at least 5, (4) the integrator response can be dealt with using superposition of solutions and (5) the induced voltage wave can be simulated by straight-line approximations. Those factors which materially influence integrator operation are treated as separate problems. Thus, the effect of each system parameter can be analyzed and its effect on overall system operation predicted.

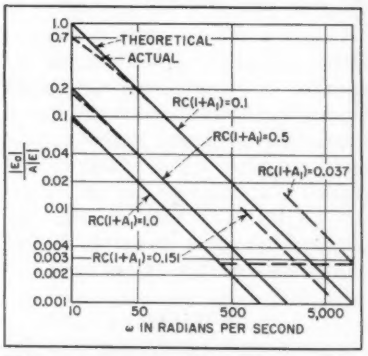


FIG. 2—Output amplitude of first amplifier stage plotted as function of frequency (theoretical and actual)

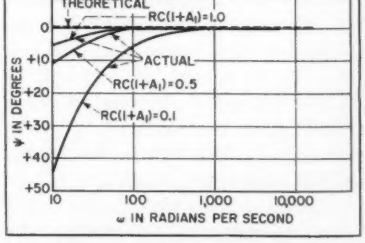


FIG. 3—Output phase angle of first amplifier stage plotted as function of frequency (theoretrical and actual)

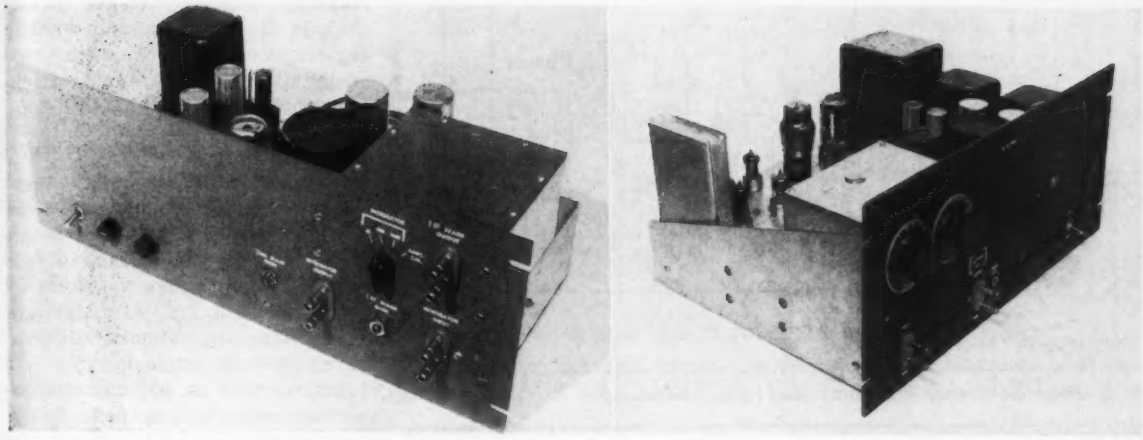


FIG. A—Integrator (left) quantitatively measures magnetic core properties to supply data used for predetermining core performance. Weak integrator output is increased to usable magnitude by amplifier (right)

Core Measurements

Initially, the design of the integrator is analyzed as though amplifiers were perfect devices having constant gain and no phase shift. This approach illustrates the manner in which the product of the R-C feedback network and the magnitude of the first-stage gain influences integration effectiveness.

A block diagram of the integrator is shown in Fig. 1. Steady state integration response of this circuit is expressed as

$$\frac{E_o}{A_1 E} = \frac{1}{\omega RC(1 + A_1)}$$

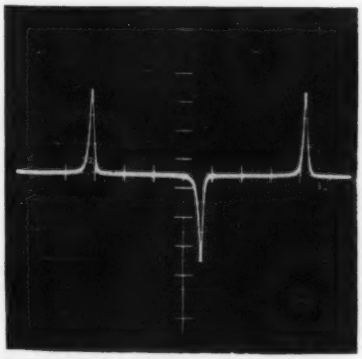


FIG. 4—Induced voltage wave generated by subjecting toroidal core made of 4-79 Molypermalloy to a 400-cps sine current excitation equivalent to 0.5 oersteds at peak. Pick-up loop consisted of two turns closely coupled to core

$$\left\{\frac{\omega^2}{[RC(1 + A_1)]^{-2} + \omega^2}\right\} \cos(\omega t + \psi) \qquad (1)$$

where E and E_o represent maximum values of the input and output signals respectively, and $\psi = 90° - \text{Tan}^{-1}\omega RC\ (1 + A_1)$.

In deriving Eq. 1, it was assumed that the complex input wave could be represented by a series of sinusoidal terms of the form $e_m = E_m \sin \omega_m t$ and that the gain of the amplifier stage would remain constant and independent of frequency. Plots of the magnitude and phase characteristics of Eq. 1 are shown in Fig. 2 and 3.

An examination of these characteristic curves indicates that relatively large values of the term $RC\ (1+A_1)$ are required if the device is to approach the action of a true integrator for all frequencies. Usually it is not difficult to obtain relatively large $RC\ (1+A_1)$ products; however, this is not in itself desirable. At any specific frequency f_1, increasingly large values of the $RC\ (1+A_1)$ product give rise to diminishing values of the term E_o/A_1E. Although the integration action becomes more nearly perfect, the output signal is diminished in magnitude and may become so small as to be unusable or obscured by internally generated system noise.

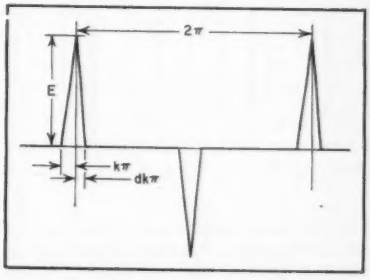


FIG. 5—Straight line approximation of induced voltage wave shown in Fig. 4

R-C Combinations

Because of the influence of the term $RC\ (1+A_1)$ upon integration effectiveness and upon output signal level, it is generally necessary to provide separate R-C combinations which can be switched into the integrator loop. One combination should be available for each test frequency normally used.

In the construction of the integrator three separate R-C combinations were employed which gave $RC\ (1 + A_1)$ products of 1 for 60 cps, 0.151 for 400 cps and 0.037 for 1,600 cps. These products were selected so that the term E_o/A_1E was the same at each test frequency.

Although selection of the value

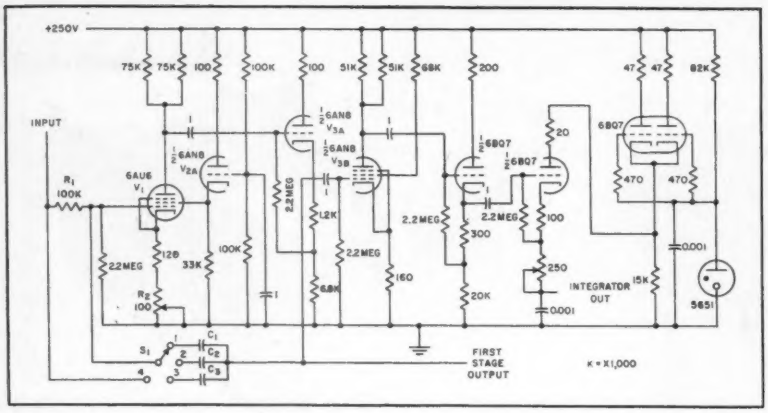


FIG. 6—Schematic diagram of integrator used for core measurement

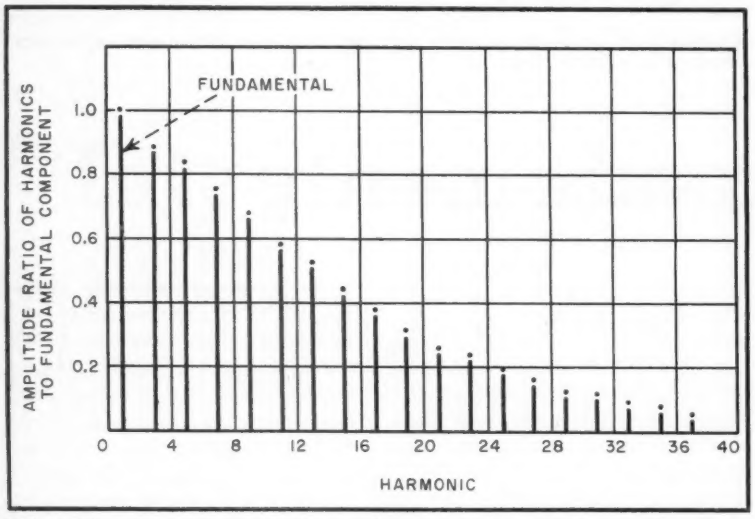


FIG. 7—Harmonic spectrum of induced voltage wave shown in Fig. 4. All even harmonics have zero amplitude for sine current excitation

of the RC $(1+A_1)$ product usually must be compromised, it can be shown that term A_1 should be as large as possible. The larger the stage gain in amplifier A_1, the larger will be the integrated output signal for any given RC $(1+A_1)$ product. The practical limit of A_1 is determined primarily by the gain-bandwidth requirement for the stage which is a function of the type of tube selected.

The integrator must possess a bandwidth of approximately 0.5 mc for proper operation. By using a receiving tube pentode in the first amplifier stage and assuming that the total stray circuit capacitance can be held between 10 and 15$\mu\mu$f, it is possible to realize gain-bandwidth factors of 45 to 60 mc. This factor, in conjunction with the bandwidth requirements, limits the first stage gain to a 90-to-120 range.

It has been experimentally determined that the first-stage amplifier can possess a phase shift of approximately ¼ of a deg at the fundamental, or excitation, frequency without introducing noticeable error. If the amplifier is considered to be a simple, single-stage, R-C-coupled amplifier with a ¼-deg phase shift, the low-frequency 3-db point ω_0 is approximately equal to $\omega/230$ which agrees with a value obtained by Lord.[1] This relationship indicates that the low-frequency response of the amplifier must be extremely good. For example, if the lowest excitation frequency is 60 cps, the low-frequency 3-db point must occur at approximately 0.26 cps. Therefore, the total integrator phase shift at 60 cps and with an RC $(1+A_1)$ product equal to one is a composite effect resulting from a 0.25-deg phase shift in the amplifier and a 0.15-deg phase shift introduced by the noninfinite RC $(1+A_1)$ integration product.

High-Frequency Requirements

In general, the induced voltage wave is nonsinusoidal and possesses many harmonics of relatively large amplitude. An oscillograph of an actual induced voltage waveform is shown in Fig. 4. An assumed straight-line approximation of this waveform is shown in Fig. 5.

Assume that an induced voltage can be represented satisfactorily by the straight-line values $K = 0.075$ and $d = 0.25$. When inserting these values in the Fourier expansion for the waveform approximation, the amplitude of the thirty-third harmonic is ten percent of the amplitude of the fundamental frequency component. Similarly, signals having higher crest factors possess correspondingly greater spectrums and require greater amplifier bandwidth for faithful reproduction of the impressed signal.

Induced voltages obtained may have crest factors as high as fifty-to-one as demonstrated by Roberts.[2] To properly reproduce a signal of this type, the high-frequency 3-db point of amplifier A_1 must occur at a frequency approximately 300 times that of the highest fundamental, or excitation frequency employed. Since the integrator is designed to operate at excitation frequencies from 60 to 1,600 cps,

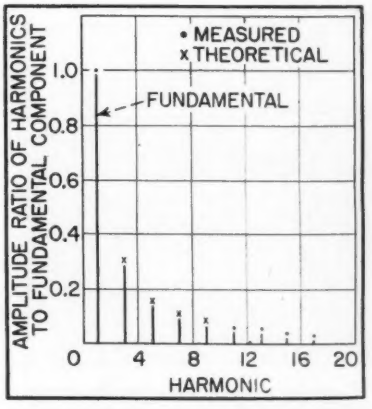


FIG. 8—Integrator output spectrum generated by input driving function shown in Fig. 4. Comparison between measured and theoretical response is also given

the overall frequency response of the first amplifier stage must extend from 0.26 cps to 0.48 mc.

Integrator Design

The integrator, shown schematically in Fig. 6, is designed in accordance with the theoretical criteria. Tubes V_1, V_{2A} and V_{2B} make up the first amplifier stage A_1. Because of the extreme low-frequency response required, no attempt was made to by-pass the cathode circuit of V_1. Resulting current feedback reduces the overall first stage gain from a theoretical value of 100 to a value of 50. At the same time, a certain amount of gain stabilization is produced.

Screen degeneration is reduced to a small value by supplying the screen from cathode-follower stage V_{2B}. The integration R-C loop is made up of the input resistor R_1 and one of the three capacitors C_1, C_2 and C_3. First-stage gain can be set precisely to a value of 50 by placing switch S_1 in position 4 to open the integration loop and then adjusting cathode resistor R_2.

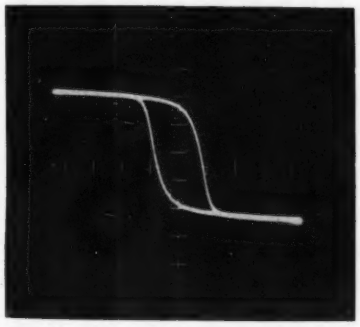


FIG. 9—Flux-current loop out of integrator as seen on cro

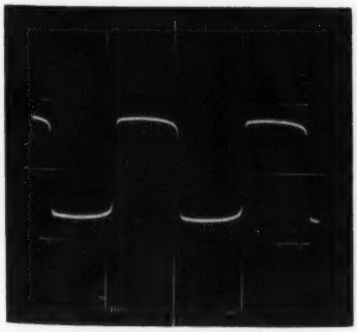


FIG. 10—Integrator output voltage generated from driving function shown in Fig. as seen on cro

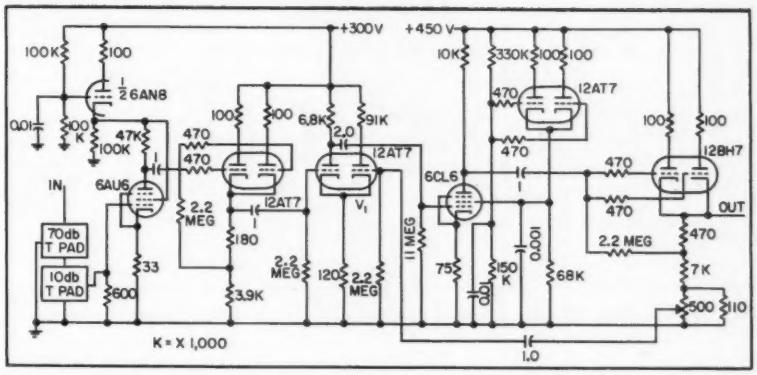


FIG. 11—Amplifier schematic. Special feedback technique minimizes phase shift over 0.3-cps to 650-kc range at the 3 db points. Gain without feedback is 12,500

Remainder of the integrator circuit is made up of a wide-band, moderate-gain amplifier and cathode-follower designed to work into a 600-ohm, resistive T-pad attenuator. Overall open-loop gain of the integrator is adjusted to a value of 740 which, in turn, makes the second stage gain 14.8. With this gain established, open-loop rms noise output with shorted input is 6 mv. Overall closed-loop gain at the fundamental frequency is precisely 2 as can be determined from Fig. 2.

Peak-to-peak output voltage is related to the peak flux in the core by the integration constant of the integrator. This is expressed as

$$\Phi = KE_{coil\,p-p}$$

where Φ = peak flux and

$$K = \frac{RC(1 + A_1)10^8}{2A_1A_2n}$$

where n is the pick-up coil turns.

Integrator Performance

To evaluate the performance of the integrator, the harmonic spectrum of the induced voltage wave, shown in Fig. 4, was measured using a GR type 736-A wave analyzer. A plot of the spectrum appears in Fig. 7. With this input signal applied, the integrator output signal spectrum was similarly measured and is as in Fig. 8.

Ideally, the integrator response should fall off at a rate of 6 db per octave; therefore, the integrator performance was compared, component by component, with the theoretically determined performance. This has been done and is in the spectrum shown in Fig. 8. Examination of the graph indicates that the integrator matches the theoretical performance within the accuracy obtainable from the measuring method used. Traces of the flux-current loop signal and output voltage from the integrator are shown in Fig. 9 and 10.

Amplifier Design

Since the closed loop integrator gain is only two at fundamental frequencies, it is usually necessary to provide additional amplification of the output signal for measurement and cro display purposes. To fulfill this need, a wideband amplifier with 80-db gain was designed.

Bandwidth requirements are the same as previously specified for the integrator if the amplifier is to precede the integrator. However, if the amplifier is used following the integrator, the high-frequency response does not need to be as good.

A schematic diagram of the amplifier as actually constructed is shown in Fig. 11. The design is straightforward except for the method of inserting the main feedback signal.

Since the bandwidth is relatively great, 0.3 cps to 650 kc at the 3-db points, it is very important that phase shifts in the feedback loop be minimized over the whole range. Therefore, the feedback signal is applied to one grid of dual-triode amplified V_1 and is combined with the main path signal in the common resistor of the same stage.

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(1) H. W. Lord, Dynamic Hysteresis Loop Measuring Equipment, *AIEE Trans*, p 269-272, vol LXI, 1942.

(2) R. W. Roberts, Magnetic Characteristics Pertinent to the Operation of Cores in Self-Saturating Magnetic Amplifiers, *AIEE Trans*, p 682-689, vol LXXIII, part I, 1954.

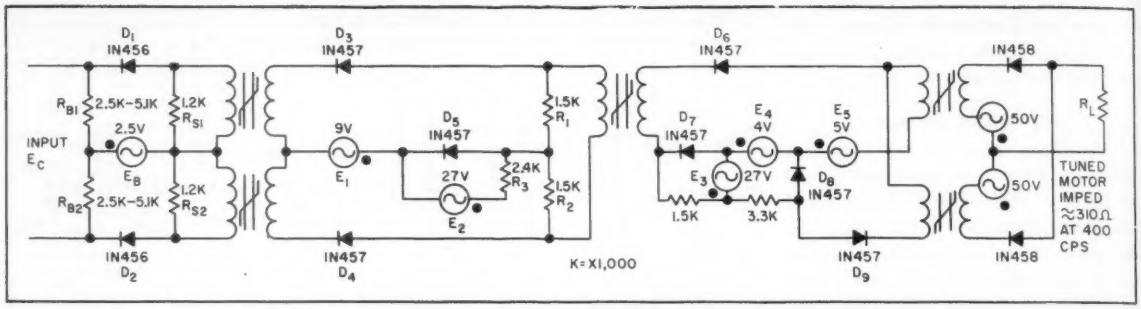


FIG. 1—Basic gyro indicator amplifier has 300 deg per sec follow-up rate, ±0.5-deg accuracy and ±0.25-deg zero drift

Three-stage fast-response magnetic servo amplifier occupies only 22 cubic inches in military airborne gyroscope indicator. Amplifier has balanced two-core input, alternate-firing output stage and synchronous interstage switches to eliminate interaction between stages. Power gain approaches 60 db with less than ±¼-deg zero drift

By CLIFFORD C. VOICE Electrical Design Section Head, Lear Incorporated, Grand Rapids, Michigan

Magnetic Amplifier

THERE HAS BEEN considerable activity in recent years toward the application of fast-response magnetic amplifiers in high-performance servo systems. Availability of silicon diodes within the last two years has made the use of magnetic amplifiers attractive for military and airborne applications where extreme environments are encountered. These amplifiers are rugged, yet may still be small and light weight, even to the extent of comparing favorably in size and weight with equivalent transistor circuits in many applications.

One particularly challenging military airborne application required a 3-in. vertical gyro indicator with self-contained servo amplifiers. The amplifiers could not be mounted with the gyro as in other systems, as this aircraft employed a master gyro reference system. Other requirements were for a fast response, a 300 deg per sec follow-up rate and ±0.5-deg accuracy.

Accuracy requirements dictated a required amplifier power gain approaching 60 db, considering the power limitations of the velocity generator output. One watt of control power was required by the servo motor for rated performance.

Half-wave magnetic amplifiers were chosen for their fast response and small size.

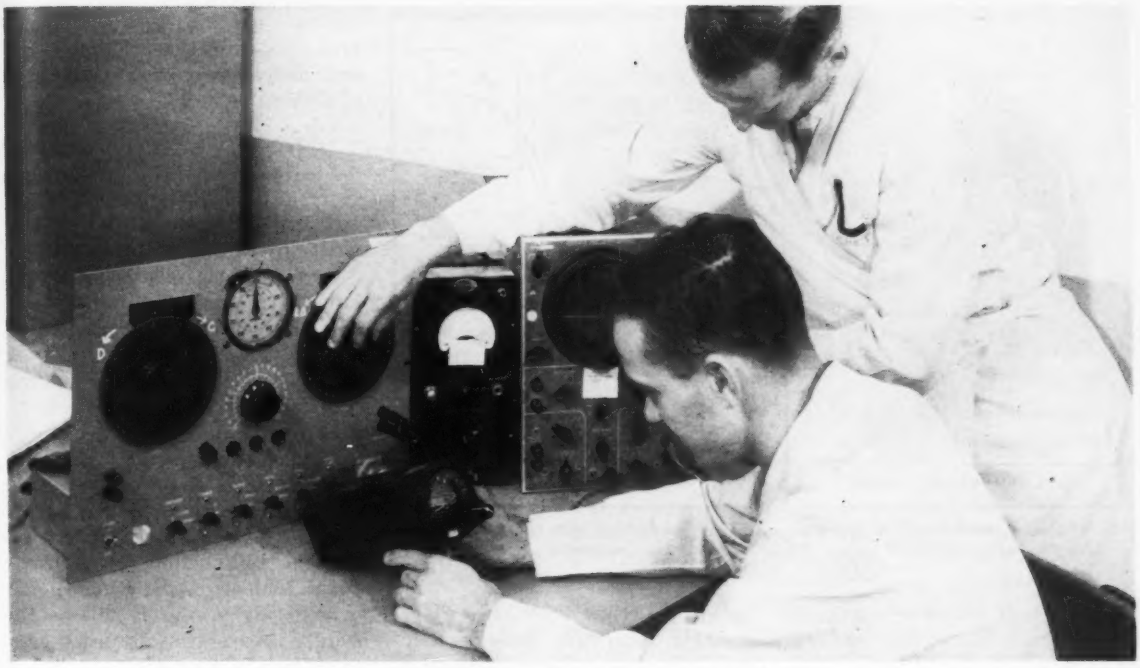
Circuit

Since a half-wave amplifier is limited to about 20 db of gain at these low power levels, a three-stage amplifier is required. Only five reactor assemblies are required for the complete amplifier shown in Fig. 1. Supply voltages are shown as voltage generators to simplify the schematic. Many of these voltages can be obtained from a common transformer secondary winding with appropriate taps.

The input stage employs a two-core balanced (differential) configuration with each core biased near the middle of its linear range. The diodes are so arranged that both cores are reset during the same half-cycle of the supply voltage. Such an arrangement has inherent half-cycle response, eliminating the possibility of induced voltages in the control windings creating a time-constant effect.

Biasing for the first stage is obtained from voltage E_B acting through R_{B1}, D_1, R_{B2} and D_2 on reset half-cycles. During output half-cycles, E_B blocks D_1 and D_2 preventing current flow through the signal source due to induced voltages. Since the signal is connected to the control winding only during the reset period, it need only supply the incremental current required to increase or decrease the flux reset.

Theoretically the input impedance would be infinite (zero signal current flow) if the usual idealized rectangular hysteresis loops are assumed. Realistically, however, a finite input impedance exists since the flux reset versus half-cycle average current always exhibits a definite slope. The reactors used in this



Complete gyroscope-indicator magnetic-servo-amplifier unit is checked out on test bench

Drives Gyro Indicator

design typically exhibit a 5,000-ohm incremental impedance.

Bias Stabilization

Resistors R_{B1} and R_{B2} provide bias stabilization for the input stage by reducing the effective source impedance of the bias network, while permitting E_B to be large enough to cause positive switching of D_1 and D_2.

Output of the first stage is obtained as the differential voltage arcoss R_1 and R_2. The synchronous switch circuit comprising E_2, R_3 and D_5 connects E_1 to the junction of R_1 and R_2 during output half-cycles. During reset half-cycles, D_6 is blocked, developing a reverse voltage equal to E_2 across it, while D_3 and D_4 are blocked by a voltage equal to $E_1 + E_2$. This produces positive blocking action, preventing any interaction effect between the first two stages. Additionally, it allows the first stage to fully utilize nonsinusoidal input signals such as pulses without saturation effects.

The second stage consists of a single-core amplifier biased for one-half reset (90-deg firing angle in the output) for zero signal. In practice no bias supply is used, but instead the first stage is intentionally biased away from null to produce the required output from the second stage by the proper selection of R_{B1} and R_{B2}. An input signal then advances or retards the second stage output firing angle, depending on the signal polarity.

Synchronous Switching

Synchronous switches are used in the output of the second stage. They operate such that D_8 and D_9 are blocked during the output half-cycle for the second stage. At the same time, D_7 conducts to tie supply voltage $E_4 + E_5$ between the second stage and the control winding of the third stage upper core, which becomes the second stage load.

The third stage lower core is completely isolated by the switching action during this period. During reset periods for the second stage, D_8 is blocked by a voltage equal to $E_3 + E_4 + E_5$ due to the switching action of D_7.

The third stage uses two cores in an alternate output firing arrangement.[1] The upper core receives its input from the second stage, whereas the lower core is actually reset by the third stage upper core one half-cycle later.

Each core will have one-half output (90-deg firing) for zero-signal conditions. The firing angle of one is then advanced while the other is retarded as signal is introduced. Null and full output waveforms are shown in Fig. 2. Note that the fundamental a-c component is polarity reversing, although a unidirectional d-c signal is also present.

Core Reset

While the upper core is being reset by the second stage, D_8 and D_9 are blocked, isolating the lower core control winding. On the following half-cycle (the reset period for the

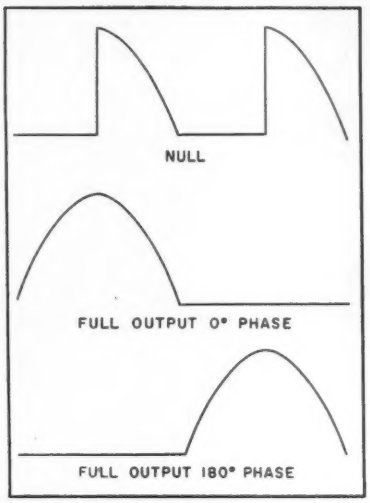


FIG. 2—Output waveforms of amplifier for three different conditions

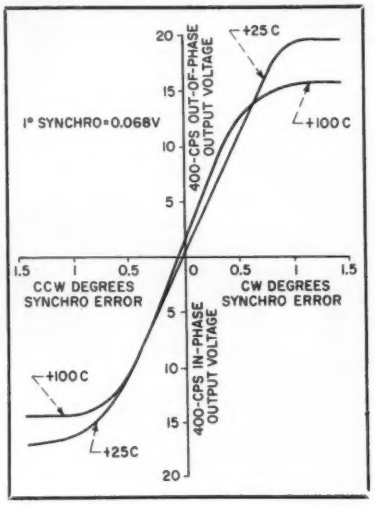


FIG. 3—Amplifier gain curves measured with in-phase voltmeter

lower core), D_3 conducts due to the action of $E_3 + E_4$; D_5 also conducts due to E_5 which now becomes a bias voltage.

The amplitude of E_5 is sufficient to fully reset the lower core, if no other voltages are present. However, acting in series with E_6 is the control winding of the upper core which is in its output half-cycle. Until the upper core saturates, it will have an induced voltage present on its control winding which opposes E_5. Since the flux change required to saturate a core is equal to the total flux reset received, this induced voltage is proportional to the last previous reset voltage received by the upper core and so may be used to drive the lower core.

This arrangement causes the reset of the lower core to increase as the reset of the upper core is decreased, producing the desired operation.

The switching is such that the induced voltage in the control winding of the lower core never influences the upper core. Thus the half-cycle response of the upper core is preserved. The lower core is then essentially a slave stage,[2] producing its output one half-cycle later.

Circuit Advantages

The alternate firing arrangement of the output stage is preferred over any simultaneous firing configurations because of its higher efficiency. This may not be immediately obvious, since both cores are biased for 90-deg firing. However, in simultaneous firing circuits, at null, both cores fire at the same time producing a short-circuiting effect which causes high circulating currents. No such effect occurs when alternate firing is used.

A further advantage of the output configuration is that the output signal is always in phase, either 0 deg or 180 deg, with respect to the supply voltage regardless of output amplitude. The resultant gain curves, shown in Fig. 3, as measured with an in-phase voltmeter are extremely linear, showing no sign of dishing at null.

Circuit Analysis

The theory of using synchronous switches in magnetic amplifiers has appeared in the literature[3, 4] and is too lengthy to repeat in detail here. However, a brief discussion of the essential features is in order, as it has considerable influence on the individual reactor designs and on the overall performance of the system.

Figure 4A illustrates a test circuit representative of a single core amplifier such as the second stage of the indicator amplifier. Test switch S_1, when closed, allows the amplifier to function in a conventional manner. With S_1 open, the synchronous switch is allowed to operate. Waveforms for each case are shown in Fig. 4B.

The available blocking voltage for the output rectifier during the reset period is E_1 with S_1 closed, whereas it is $E_1 + E_s$ with S_1 open. Signal voltage E_c, while resetting the core, will induce a voltage in the output winding which will oppose E_1 and E_s.

Should the induced E_c exceed E_1 with S_1 closed, the shaded portion of E_c would be lost due to unblocking of the rectifier and the resultant current would load the signal source by transformer action. With S_1 open, the synchronous switch increases the blocking voltage and permits the full use of such non-sinusoidal waveforms.

To reset fully the test circuit of Fig. 4A, the reset volt-seconds must equal the gate circuit supply volt-seconds ($\int_0^\pi E_1 dt$). With a synchronous switch, full reset can be achieved with a narrow pulse,

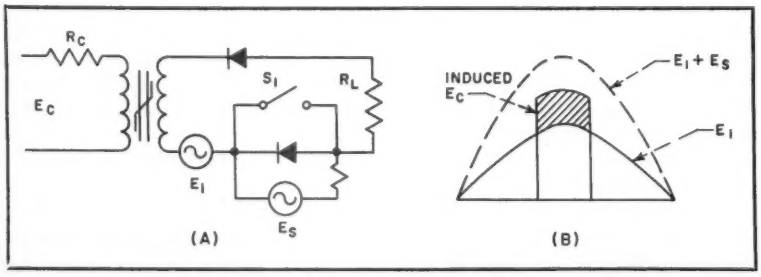


FIG. 4—Single-core test amplifier (A) and output waveforms (B) with S_1 open and closed

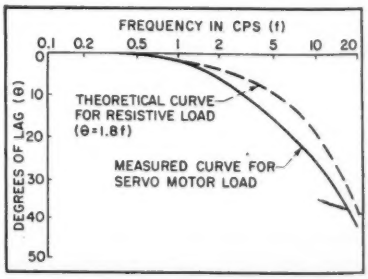


FIG. 5—Open-loop amplifier phase lag

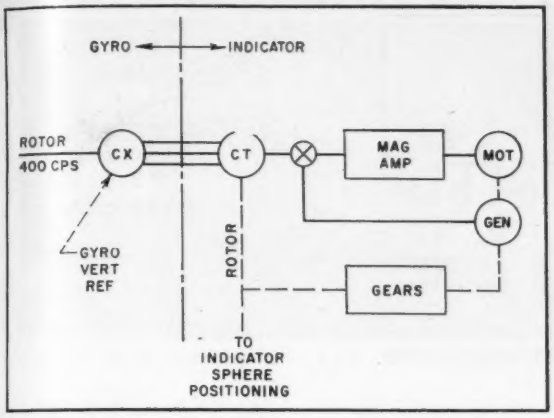
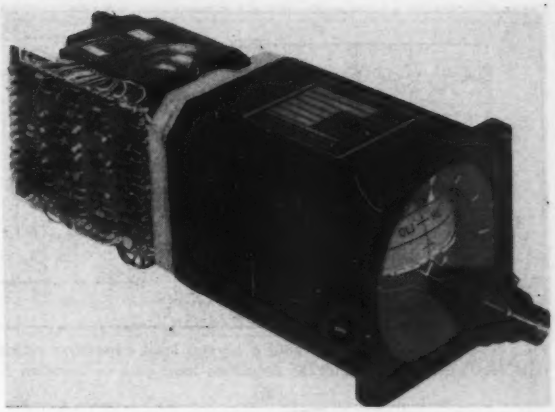


FIG. 6—Block diagram of roll-axis channel. External control for pilot is provided for trimming



Indicator unit with magnetic amplifier at rear gives relative indication of compact packaging achieved

whereas a sine wave or at least a signal voltage equaling or exceeding E_1 throughout 180 deg is required for the conventional circuit. When used, this feature permits E_c to be obtained from a previous magnetic amplifier stage and full control is achieved on the second stage for only a few degrees of firing angle variation on the first stage. Thus firing angle amplification is achieved.

Firing Angle

Firing angle amplification is used between the first and second stages of the indicator amplifier to permit use of a larger and more practical core size in the first stage. The first stage can also operate at its highest gain point, since it is a differential type and is not required to operate over its full useful range.

Additionally, and most important, due to the increased linear range on the first stage, it can integrate larger extraneous signals during the reset interval without saturation effects. This provides an inherent quadrature rejection ability of considerable importance in many applications. Whereas the indicator amplifier produces full output for approximately 0.068 v of in-phase signal, 0.5 v of quadrature will not appreciably alter its in-phase gain.

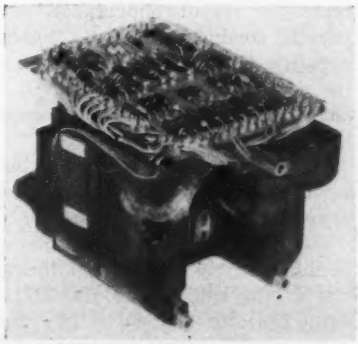
A disadvantage of using firing angle amplification is that the zero drift problem is increased since the unbalance drift will also be amplified. Shunt resistors R_{s1} and R_{s2} and/or matched input cores are used as required to minimize this effect. Typically, a zero drift of less than $\pm\frac{1}{4}$ deg has been encountered in this application for varying combinations of temperature (−55 C to +100 C), line voltage (±10 percent) and frequency (± 5 percent).

Performance

Overall performance of the amplifier in the indicator is shown in Figs. 3 and 5. The theoretical phase lag curve of Fig. 5 is predicted with the assumption of a total time delay of 2 cycles (0.005 sec). Net power gain utilized in this application is about 56 db.

Dead zone of the sphere due to friction and other factors is typically less than 0.1 deg. Dynamic lag for the system is about 5 deg at the maximum rated velocity of 300 deg per sec. Excellent damping is achieved, so that no perceptible overshoot is observed as a result of a step-input displacement command.

A prototype indicator employing half-wave magnetic amplifiers is shown in the photographs. The forward half of the package contains the sphere with its associated motor-generators, gear trains, slip rings and synchros for both the pitch and roll axes. The back half of the package contains all the associated circuits for the two channels, including two three-stage amplifiers, excitation transformers, tuning and phase-splitting capacitors.



Complete magnetic amplifier assembly

Packaging

A printed circuit board mounted on one side of the electronic assembly contains the required resistors, silicon diodes and all tie points. Reactors, capacitors and transformers are cast into an irregularly shaped block to provide maximum utilization of the available space. The complete electronic package has a volume of only 22 cubic inches.

A block diagram of the roll axis system configuration is shown in Fig. 6. The pitch axis is similar, except that a trim potentiometer is added to the synchro control transformer output to allow pilot adjustment for individual aircraft trim requirements. Velocity feedback is used in both axes to obtain maximum performance.

References

(1) W. A. Geygar, A New Type of Magnetic Servo Amplifier, *AIEE Trans*, Part I, p 272, 71, 1952.
(2) H. W. Lord, Magnetic-Amplifier Circuits with Full-Wave Output and Half-Wave Control Signals, *AIEE Trans*, Part I, p 265, 73, 1954.
(3) C. C. Voice, Fast Response Multi-Stage Magnetic Amplifiers, *Proc Nat Electr Conf*, p 411, 12, 1956.
(4) H. W. Patton, The Pulse Stretch Coupling Circuit. *AIEE Trans*, Part I, p 377, 75.

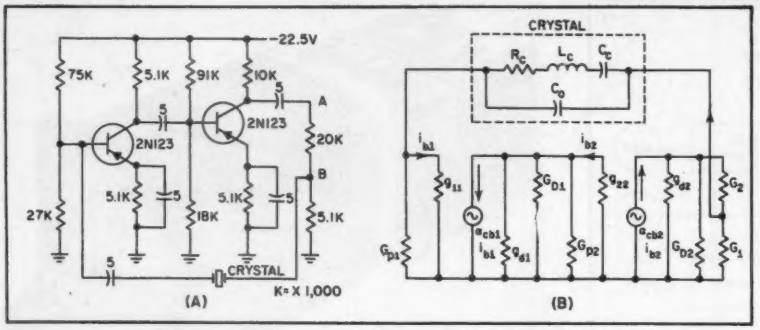


FIG. 1—Two-stage amplifier with a crystal load generates stable fixed-frequency oscillations (A); equivalent circuit (B) simplifies loop gain calculation

By G. A. GEDNEY
and
G. M. DAVIDSON

Arma Division
American Bosch Arma Corporation
Garden City, New York

Crystal Oscillator

Two-stage crystal feedback amplifier operates at 9.1 kc with long-term frequency stability of a few parts per million. Operating frequency can be pulled off resonance by adjustment of trimmer capacitor in series with crystal. Applications include constant-frequency power source for gyroscopic precision integrator and regulated carrier frequency for electrical resolvers, industrial generators and phase computing networks

CONVENIENT CALIBRATION adjustment may be provided in some analog and digital systems by deviating the carrier frequency by a small but accurately known amount. This article describes the design of a fixed-frequency oscillator with long-term frequency stability of a few parts per million and provision for manually varying the output frequency a few cps in calibrated increments.

Design

Requirements of a low frequency of 9.1 kc with high stability necessitated the use of a special high-Q crystal with low variation in nominal frequency over a fairly wide temperature range.

Current degeneration type biasing compensates for the effects of leakage currents flowing from collector to base. The bias stabilization network yields a factor of two to limit the fluctuation in output voltage to less than ±5 percent over the range of −65 C to +65 C.

The basic circuit for fixed-frequency operation in shown in Fig. 1A. From the equivalent circuit of Fig. 1B, when

$g_{22} \gg g_{d1} + G_{D1} + G_{P2}$, and $g_{11} \gg G_{P1}$,

the loop current gain of the amplifier is

$$K_i \cong \left(\frac{a_{cb1}\, a_{cb2}\, G_{L2}}{g_{d2} + G_{D2} + G_{L2}}\right)\left(\frac{G_{crys}}{G_1 + G_{crys}}\right)$$

where G_D = d-c collector load conductance, g_{11} and g_{22} = a-c input conductances of the transistors, g_d = transistor output conductance, G_p = parallel conductance of the biasing network, G_{L2} = total conductance of the attenuation network and G_1 = conductance of one leg of attenuating network.

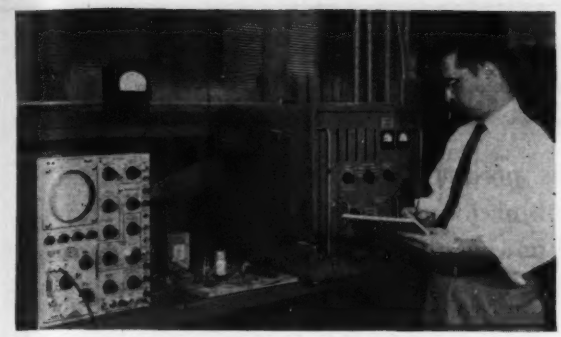
Current gain of the amplifier varies from 20 to 500 at crystal resonance depending on transistor β.

Output amplitude of the oscillator is limited only by the nonlinearities in the loop. Since the 2N123 has a Zener breakdown of 16 v that varies with age, temperature and unit, provision must be made to prevent an output rise to 16 v. Also the maximum allowable voltage across the crystal is 1 v. The circuit can be designed to limit the output to any desired value lower than the Zener value by shaping the d-c and a-c-load lines. The relatively high collector supply voltage is needed for bias stabilization.

Crystal Pulled Off Resonance

Oscillation frequency may be varied by inserting a 1 to 100-$\mu\mu$f trimming capacitor, in series with the crystal and adjusting it to the desired frequency. Since the circuit only oscillates when the phase shift around the loop is zero, the crystal acts as an inductance at the new resonant frequency and the loop gain is larger than one.

The effective feedback circuit resistance increases as the square of the change in frequency from resonance thereby increasing the attenuation of the feedback circuit and requiring a larger open-loop gain.



Engineer records observations of 9.1-kc oscillator performance

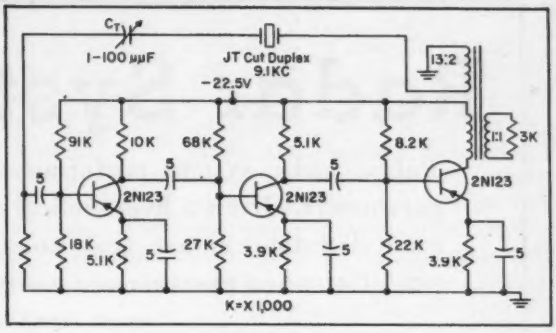


FIG. 3—Three-stage crystal oscillator provides greater power output

Has Variable Frequency

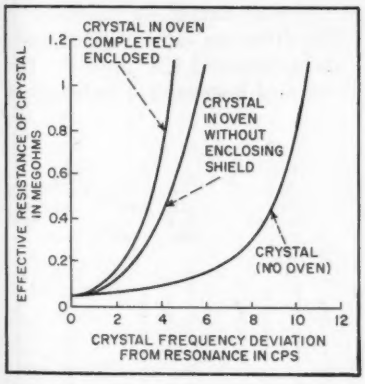


FIG. 2—Crystal resistance as function of deviation from resonant frequency of 9,100.6 cps with crystal partially or entirely enclosed within oven

The effective crystal resistance may be found from R_e where

$$R_e \cong R/[1 - (4\pi L\Delta f/X_{co})]^2$$

and effective reactance from

$$X_e \cong 4\pi L\Delta f/[1 - (4\pi L\Delta f/X_{co})]$$

where R, L and X_{co} are crystal constants at series resonance valid when

$$f_{ser} < f_{ser+\Delta f} < f_{antires.}$$

Crystal Parameters

To measure effective resistance R_e and reactance X_e of the crystal as a function of frequency deviation Δf from crystal resonance. A known value of capacitance is inserted in series with the crystal and the oscillator frequency is varied to obtain maximum transfer. Frequency of the oscillator is measured at maximum voltage transfer.

Measurements were performed with the crystal partially and completely oven enclosed for several values of capacitance inserted in series with the crystal. Curve 1 of Fig. 2 shows a rapid increase in feedback circuit resistance as frequency deviates from resonance indicating that the gain of the amplifier must be high to obtain a moderate frequency pull.

When the circuit requires a minimized frequency drift, the crystal should be enclosed in a constant-temperature oven to minimize temperature variation effects. This increases the parallel capacitance across the crystal and also the attenuation of the circuit as a function of frequency deviation. Therefore, for the same gain in the forward loop the crystal cannot be pulled as much. The increased gain required is illustrated in Fig. 3.

Amplifier Requirements

The amplifier must provide sufficient gain to insure a loop transmission of one, under maximum frequency pull off and yield a net phase shift around the loop of 360 deg with the crystal inserted in the circuit. Since the desired circuit frequency is a variable, each amplifier must be trimmed individually. The current flowing into the base of stage 1 is proportional to the output voltage divided by the crystal impedance. With the output voltage constant the base current swing at resonance is approximately 40 to 60 times the base current swing for a 5-cps pull off resonance.

Though all the amplifier stages tend to saturate, excessive saturation of the first stage is undesirable. The design must allow for this swing or the input current to the first stage must be attenuated by insertion of a trim resistor in series with the crystal. Value of the trim resistor is determined by the required deviation. At resonance where the loop gain is maximum the desired attenuation would be large; zero attenuation is necessary when the circuit is more than 5 cps off resonance.

The circuit of Fig. 1A was developed to yield a maximum pull off resonance of approximately 5 cps.

Impedance the external load must be about 0.3 megohm or more at point A in Fig. 1A. If the load is taken from point B, the combination of load and attenuating resistor should be equal to 5,000 ohms.

Greater Deviation

To obtain a larger frequency deviations off resonance or larger power output, a higher circuit gain is necessary. The circuit of Fig. 3 uses a transformer to obtain a phase reversal and to reflect the desired a-c load line to limit the output swing of the transistor.

Radar System Planning

Pulsed radar system performance is predicted on the basis of selected parameters. Given a hypothetical combination of operating conditions, minimum detectable signal, peak radiated power, maximum free-space range and size of antenna aperture are easily forecast

By CHESTER W. YOUNG

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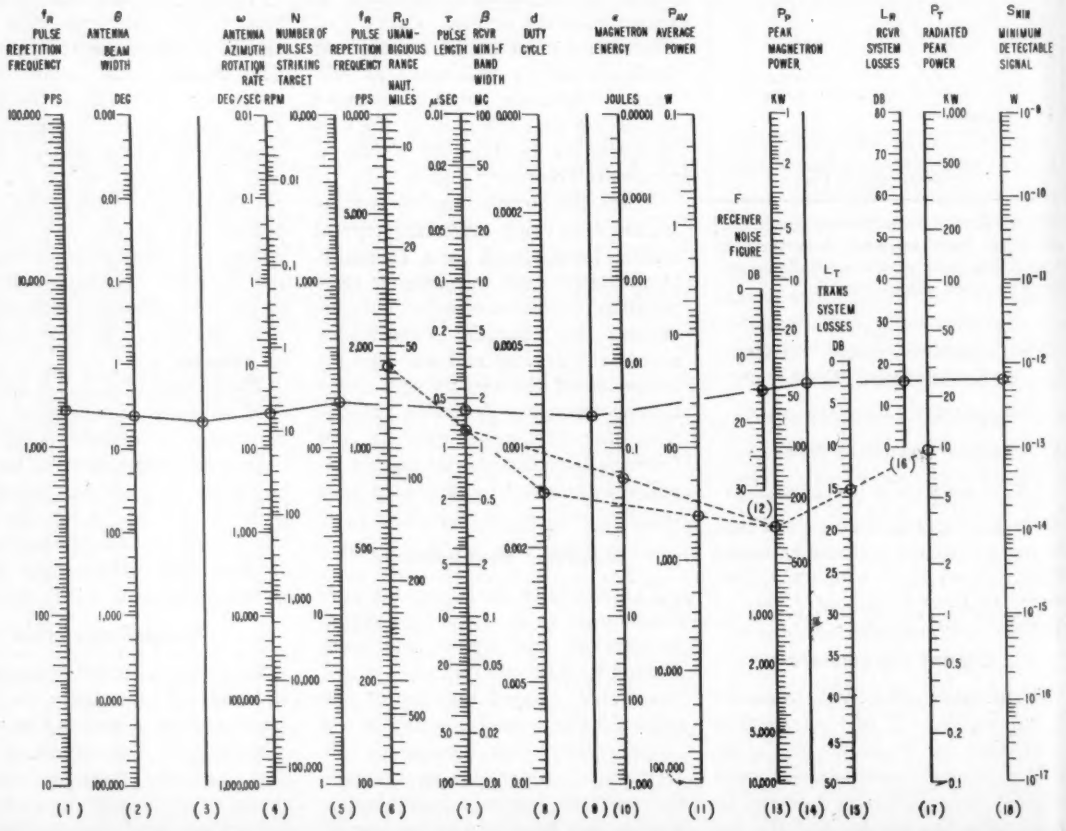
SYSTEM ENGINEERING planning often involves compromises dictated by the boundary conditions of the state of the art. The nomograph provides a method of observing quickly the outcome of trial and-error choices in making such compromises in design of radar systems. It is not a substitute for the design of individual elements of the radar but is rather a method of estimating the magnitude of the system parameters.

Approximations Made

Several assumptions have been made to simplify the nomograph. Signal-to-noise ratio was set at unity. The $\beta\tau$ product was assumed to be one rather than the optimum of 1.2. An illumination factor of 0.65 was assumed. The system losses were forced to bear the weight of all other factors.

To determine S_{MIN}, assuming a visibility factor of 1, draw a line from the value of f_R on scale 1 (example 1,707 pps) to the value of θ on scale 2 (example 4



deg) and extend it to turning scale 3. From this point draw a line through ω on scale 4 (example 36 deg/sec or 6 rpm) to scale 5 (example 190 pulses). Draw a line from this point through β on scale 7 (example 1.7 mc) to turning scale 9.

Align this point with F on scale 12 (example 15 db) and extend to turning scale 14. Draw a line from this point through L_R on scale 16 (example 15.5 db) to scale 18 (6.5×10^{-13} w).

Peak Radiated Power

The method of calculating P_T is determined by the information available. If f_R, τ and P_{AV} are known draw a line from f_R on scale 6 (example 1,707 pps) through τ on scale 7 (example 0.8 μsec) to d on scale 8 (example 0.00137).

From this point align P_{AV} on scale 11 (example 410 w) with P_P on scale 13 (example 300 kw). If ϵ is known rather than P_{AV}, draw a line from τ on scale 7 (0.8 μsec) through ϵ on scale 10 (0.24 j) to P_P on scale 13.

Draw a line from this point through L_T on scale 15 (15 db) to P_T on scale 17 (9.5 kw). Conversely if P_P, τ and d are known, then ϵ and P_{AV} can be determined.

Maximum Free-Space Range

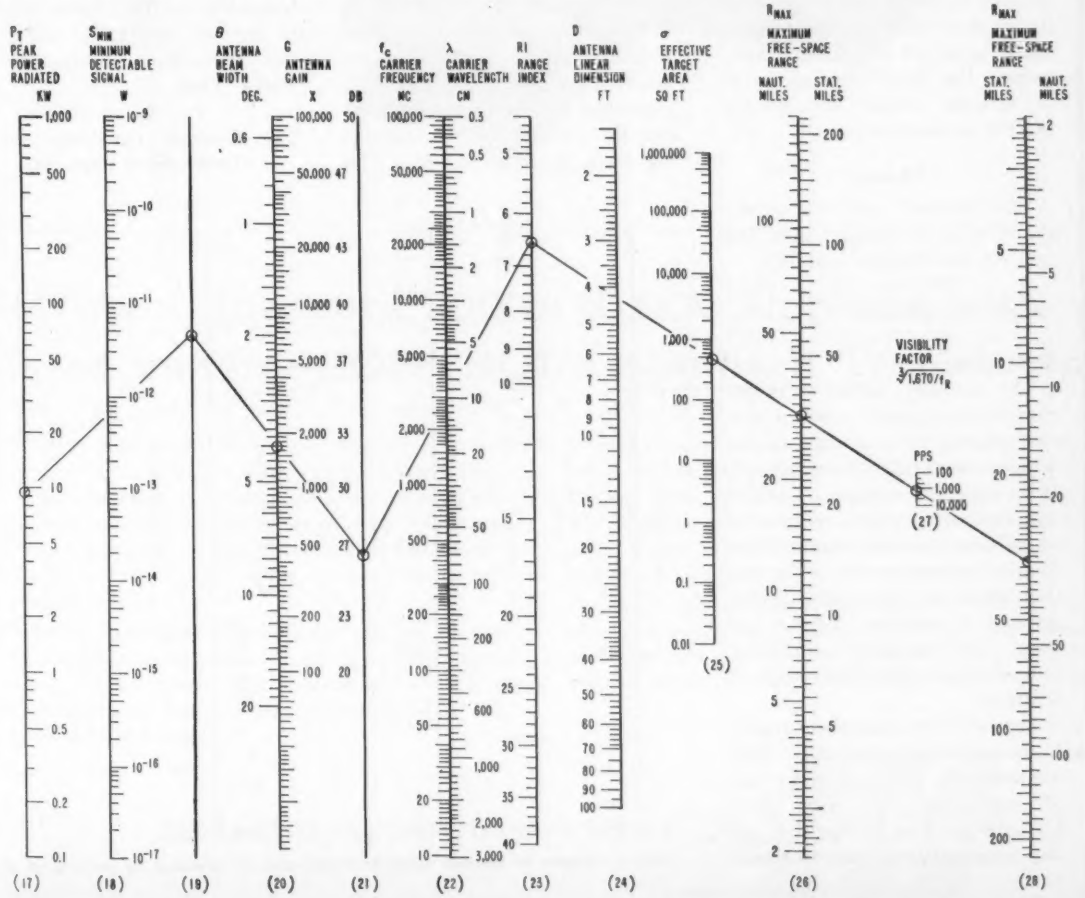
To solve for R_{MAX} draw a line joining P_T on scale 17 (9.5 kw) and S_{MIN} on scale 18 (6.5×10^{-13} w) and extend to turning scale 19.

Align this point with either θ or G on scale 20 (example 4 deg or 1,700) and extend the line to scale 21. Draw a line joining this point to the value for either f_C or λ on scale 22 (example 2,900 mc or 10.3 cm) and extend it to RI on scale 23 (example 6.5).

Draw a line from this point through σ on scale 25 (example 500 sq ft) to R_{MAX} on scale 26 (example 30 naut. miles or 35 stat. miles). If it is desired to apply the visibility factor, the result will be modified by passing a line from the point on scale 26 through V on scale 27 (example 1,707 pps) to R_{MAX} on scale 28 (29.5 naut. or 34 stat. miles).

Any pulse repetition frequency selected must have $f_R \leqq 80{,}000/R_U$. This will prevent second-time-around echoes. Thus the values of R_{MAX} on scales 26 and 28 must always be less than the unambiguous range R_U equivalent to the repetition rate f_R chosen on scale 6.

To find the physical size of the aperture of the antenna, join the value of θ or G on scale 20 (example 4 deg or 1,700) with f_C or λ on scale 22 (example 2,900 mc or 10.3 cm) and extend to D on scale 24 (example 6 ft).


P_T PEAK POWER RADIATED KW
S_{MIN} MINIMUM DETECTABLE SIGNAL W
θ ANTENNA BEAM WIDTH DEG.
G ANTENNA GAIN X DB
f_C CARRIER FREQUENCY MC
λ CARRIER WAVELENGTH CM
RI RANGE INDEX
D ANTENNA LINEAR DIMENSION FT
σ EFFECTIVE TARGET AREA SQ FT
R_{MAX} MAXIMUM FREE-SPACE RANGE NAUT. MILES
STAT. MILES
VISIBILITY FACTOR $\sqrt[4]{1.8TO/f_R}$
PPS
(17) (18) (19) (20) (21) (22) (23) (24) (25) (26) (27) (28)

Designing Stability into Transistor Circuits

Chart and nomographs simplify calculation of transistor circuit and cooling-facility parameters necessary for stable operation at elevated junction temperatures. Design information is applicable to both germanium and silicon transistor circuits

By STANLEY SCHENKERMAN

Senior Engineer, Missile Development Division, Ford Instrument Company, Long Island City, N. Y.

TO ACHIEVE THERMAL STABILITY of transistorized equipment at elevated junction temperatures, the designer must provide a circuit compatible with its cooling facility. The accompanying graph and nomographs permit the rapid determination of suitable circuit and cooling facility parameters.

Theory

The thermal stability nomograph, Fig. 1, is based upon the criteria for thermal stability[1]

$$SV_cI_s\theta < 13 \qquad (1A)$$

for germanium and

$$SV_cI_s\theta < 23 \qquad (1B)$$

for silcon.

The stability factor[2] S is the change in quiescent collector current caused by a change in the temperature sensitive component, V_c is collector voltage, I_s is the temperature sensitive component of collector current and cooling-facility characteristic θ is the thermal resistance from collector junction to ambient in deg C per watt. The designer's objective is to obtain compatible values of S and θ.

Temperature sensitive current I_s increases exponentially with temperature, doubling every 9 C for germanium and every 16 C for silicon. The value of I_s at any temperature T may be found from Fig. 2 if the value of I_{s_0} at any temperature T_0 is known; the latter values can be obtained from the manufacturer's data sheet.

Thermal resistance θ consists of the resistance from collector junction to mounting base, θ_{jm}, (specified by the manufacturer) and the resistance from mounting base to ambient, θ_{ma}. The latter may be determined experimentally from

$$\theta_{ma} = \Delta T/P_d \qquad (2)$$

where ΔT is the mounting base temperature rise above ambient in degrees centigrade and P_d is the transistor dissipation in watts. Then

$$\theta = \theta_{ma} + \theta_{jm} \qquad (3)$$

The thermal resistance nomo-

(continued on page 124)

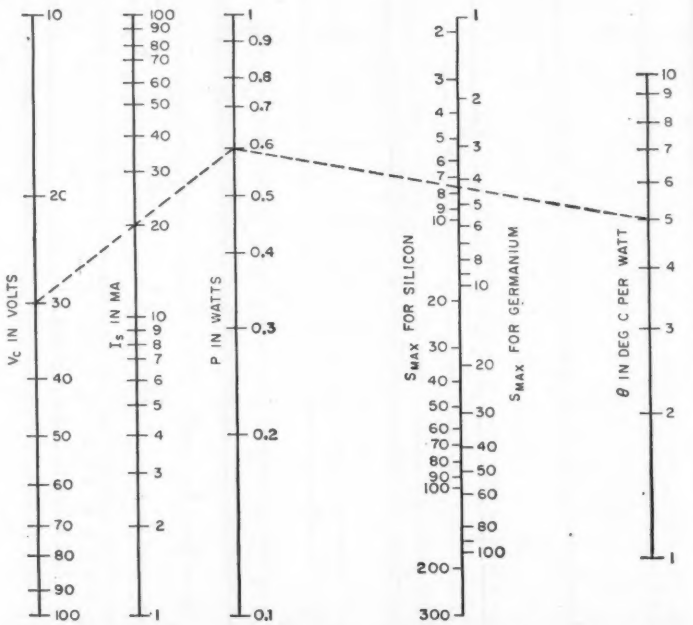
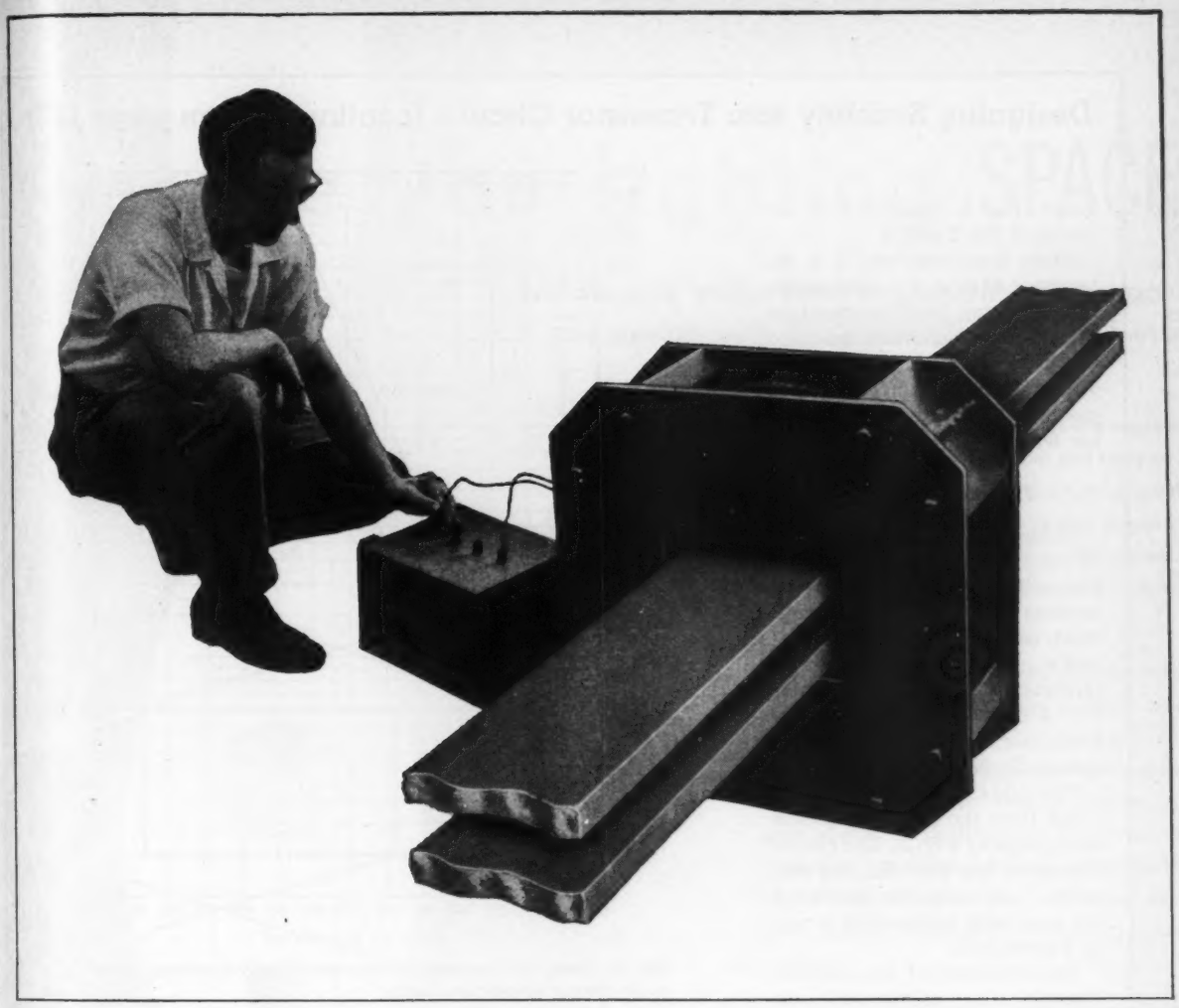


FIG. 1—Range of thermal stability nomograph is extended by powers of 10



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CONTROL transductors are saturable reactors, through which the bus or cable passes. Output is linearly proportional to the bus current, with an accuracy to ± 1% of full scale reading. Supply voltage variations of ± 10% will not affect this accuracy.

In addition to eliminating the need for breaking into the circuit for connections, the CONTROL transductor has another major advantage over the shunt-millivoltmeter. The transductor will deliver relatively large amounts of power to permit such things as overload relaying and to permit a feedback signal for a magnetic amplifier.

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Reliability begins with CONTROL

A DIVISION OF MAGNETICS, INC.

Designing Stability into Transistor Circuits (continued from page 122)

graph, Fig. 3, facilitates the solution of Eq. 2 and 3.

From measurements, it is determined that at 4 w dissipation, the mounting base temperature of a transistor, when installed in the cooling facility, is 8 C. The resistance from junction to mounting base is specified as 3 C per watt.

Thermal Resistance

Using Fig. 3, connect the point $\Delta T = 8$ C with the point $P_d = 4$ w with a straight line that intersects $\theta_{ma} = 2$ C per watt. Next, connect $\theta_{ma} = 2$ C per watt and $\theta_{jm} = 3$ C per watt with a straight line. This line intersects $\theta = 5$ C per watt which is the total thermal resistance of the cooling facility.

The value of S_{max} may now be found from the thermal stability nomograph of Fig. 1. The circuit S must be less than S_{max} for stability. Conversely, for a given S the maximum permissible θ may be determined.

The transistor of the previous example is a germanium unit with $I_{co} = 0.2$ ma at $T_o = 25$ C. It is desired to operate this unit with $V_c = 30$ v at 85 C in the cooling facility for which $\theta = 5$ C per watt. Since $T - T_o$ is 60 C, I_c/I_{co} is 100 as determined from Fig. 2. Then I_c is 20 ma at 85 C.

On the stability nomograph, Fig. 1, connect $V_c = 30$ and $I_c = 20$ with a straight line that intersects the P scale at 0.6. Now connect this point by a straight line with $\theta = 5$. This line intersects S_{max} for germanium at 4.3. This is the maximum value of S for which the circuit is thermally stable.

REFERENCES

(1) Specification for H-5, H-6, and H-7 Power Transistors, Transistor Div., Minneapolis Honeywell Regulator Co., p 9, May 1956.

(2) R. F. Shea, "Principles of Transistor Circuits", John Wiley Sons, Inc., p 97, 1953.

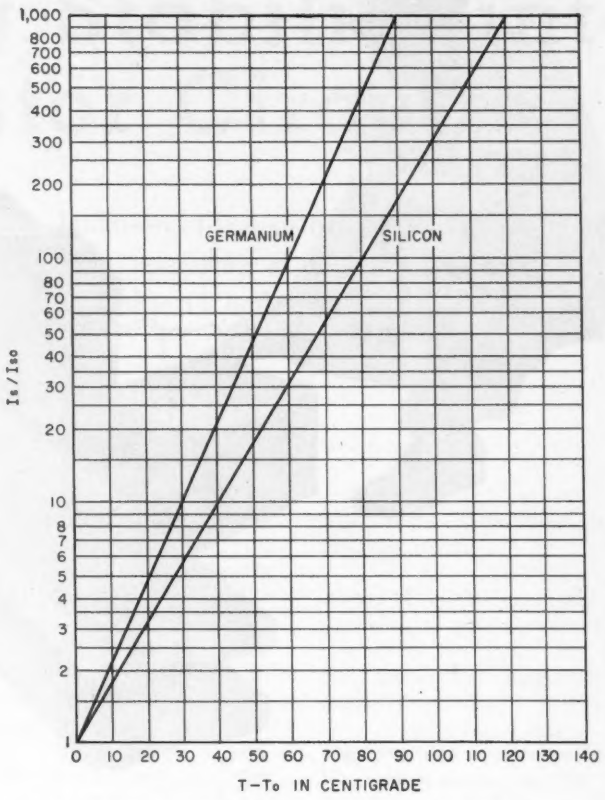

FIG. 2—Curves give normalized temperature-sensitive leakage current as function of temperature change

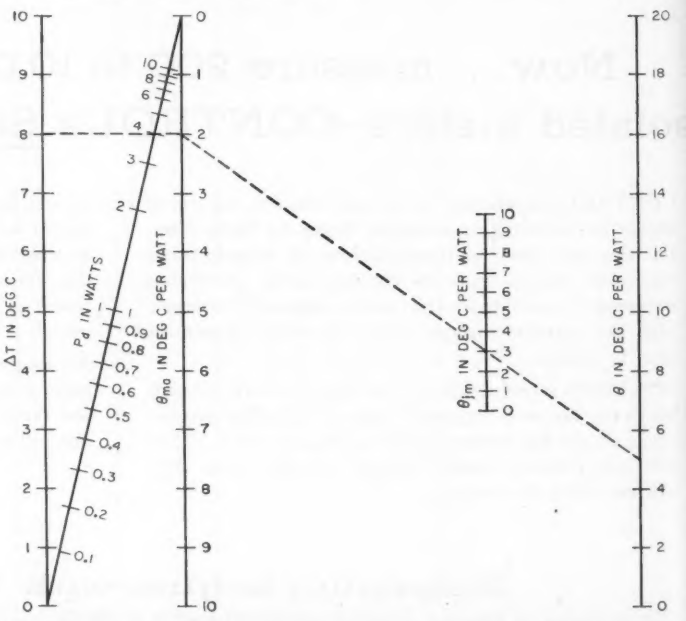

FIG. 3—Range of thermal resistance nomograph is extended by powers of 10

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Built-In Ion Trap Protects Cathode

By William Ross Aiken

Director of Research, West Coast Electronics Laboratory, Kaiser Aircraft & Electronics Corp., Palo Alto, Calif.

Robert E. Heller*

Manager, Product Development, Instrumentation Division, Ampex Corp., Redwood City, Calif.

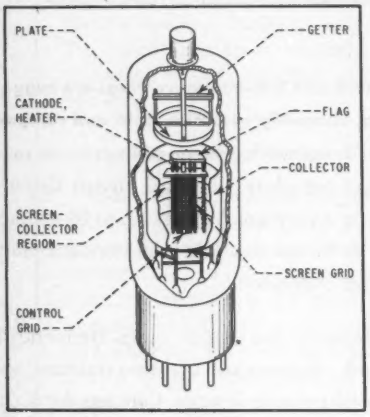

FIG. 1—Collector and flag of new pentode protect oxide-coated cathode from positive ion bombardment

LONGER LIFE for oxide-coated cathodes is made possible by a built-in ion trap. Limited quantities of a high-voltage pentode have been constructed with the ion trap and have life times in excess of 2,000 hours.

The special pentode was developed for a special high-voltage switching operation for use with the Kaiser-developed thin cathode-ray tube. Other applications may be in high-voltage triggering, clamping, mixing and shunt regulation.

Ions, created by collisions between electrons and residual gas molecules, are destructive to oxide-coated cathodes. The problem becomes more acute with higher voltages. In addition, mica supports and other insulators may develop leakage paths as a result of positive ion bombardment.

To minimize the problem, special precautions must be taken in the fabrication of high-voltage tubes with oxide-coated cathodes. For instance, the bake-out, pumping and gettering procedures must be made more thorough.

Alternately, destruction of the cathode at high voltages might be largely avoided by replacing the oxide-coated cathode with a tungsten or thoriated-tungsten emitter. However, such cathode materials imply the use of much higher filament temperatures and of more complex fabrication procedures.

In the new pentode an ion-trap is provided by which positive ions are prevented from reaching the cathode. An indirectly heated, oxide-coated cathode is surrounded by control and screen grids in the conventional manner as shown in Fig. 1. A cylindrical collector, open at one end, surrounds the screen grid and is connected to it. Thus, in the absence of plate voltage, an essentially field-free region is created in the interspace.

The plate is located opposite the open end of the collector electrode. The electric field of the plate penetrates the space between screen grid and collector, causing the electrons drifting there to be deflected to the anode. Their number is determined by control-grid potential as usual.

Positive ions created in the anode region are deflected downward toward the bottom of the collector, rather than to the screen grid or to the electrodes inside the screen. This is because the positive ions travel with a velocity whose downward component is much larger than any horizontal component.

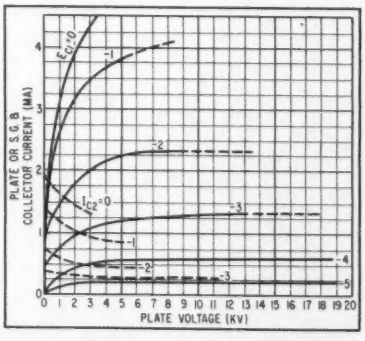

FIG. 2—Transfer characteristics with screen grid and collector at 100 volts and 6.3 volts across the filament

The only region in which positive ions can reach the cathode itself is at the end of the cathode directly opposite the plate. A small flag electrode, internally connected to the cathode, serves to prevent the entry of positive ions into the cathode region from this direction. The flag also performs the function of a corona shield.

Experimental models of the pentode were operated at 15 kv with a screen and collector voltage of 100 v. Control-grid voltage is −4 v and typical plate current is of the order of 0.6 ma. Maximum plate dissipation is 20 w, screen dissipation is 0.7 w and collector dissipation 5 w. Maximum cathode current is 10 ma.

Mutual conductance is about 600 micromhos and input and output interelectrode capacitances are 7 and 3 micromicrofarads, respectively. Heater voltage and current are 6.3 v and 0.3 amp, respectively.

*Formerly Chief Engineer, West Coast Electronics Laboratory, Kaiser Aircraft & Electronics Corp.

Oscillator Measures Tube Capacitance

By Harvey L. Morgan

Electronic Project Engineer
Phoenix Research Laboratory
Motorola, Inc., Phoenix, Arizona

MEASUREMENT of the variation in interelectrode capacitance in subminiature tubes under vibration has been achieved for a critical application. The technique may have value in tube development, as well as in similar applications.

The method involves using the slight variations in interelectrode capacitance to modulate the frequency of an oscillator. A harmonic of the oscillator is detected

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SC-32-1	0-32	0-1	0.01	0.1	19″	3½″	13″
SC-32-1.5	0-32	0-1.5	0.01	0.1	19″	3½″	13″
2SC-32-1.5	0-32	0-1.5	0.01	0.1	19″	7″	13″
DUAL OUTPUT	0-32	0-1.5	0.01	0.1			
SC-32-2.5	0-32	0-2.5	0.01	0.1	19″	3½″	13″
SC-32-5	0-32	0-5	0.005	0.05	19″	5¼″	13″
SC-32-10	0-32	0-10	0.001	0.01	19″	8¾″	13″
SC-32-15	0-32	0-15	0.001	0.01	19″	10½″	13″
2SC-100-0.2	0-100	0-0.2	0.1	1.0	19″	5¼″	13″
DUAL OUTPUT	0-100	0-0.2	0.1	1.0			
SC-150-1	0-150	0-1	0.05	0.5	19″	5¼″	13″
SC-300-1	0-300	0-1	0.1	1.0	19″	8¾″	13″

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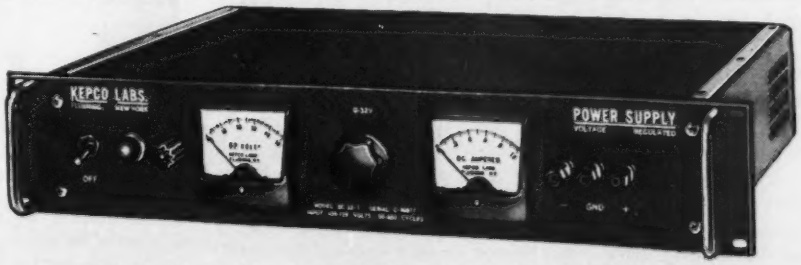

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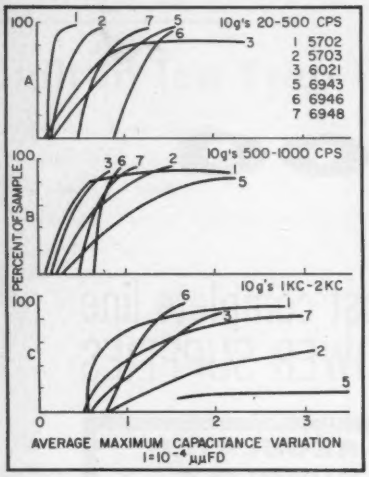

FIG. 1—Average of the maximum capacitance variations between plates and other electrodes

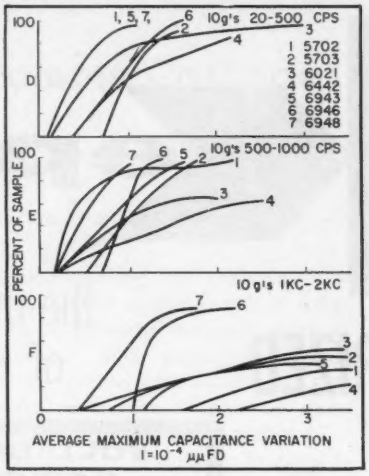

FIG. 2—Average of the maximum capacitance variations between grids and other electrodes

by an f-m receiver with a calibrated discriminator.

In the particular application, variations in capacitance on the order of 10^{-4} micromicrofarads were important. Therefore, it was necessary to be able to measure changes as small as 10^{-5} micromicrofarads.

The frequency of the transistor oscillator is about 33 mc without external loading. With the tube elements connected, the center frequency dropped to as low as 25 mc.

A linear relationship exists between frequency variation and capacitance variation. Going to the higher harmonic frequency increases the frequency change by the order of the harmonic.

In order that the entire assembly can be vibrated, the transistor oscillator is embedded in plastic. It was tested at 10 g's from 20 to 2,000 cps, and no f-m was detected with a system noise level equivalent to 10^{-5} micromicrofarads.

The tube is held in a hollowed-out aluminum block with the oscillator so that the entire assembly does not move with respect to the vibration test jig.

An important requirement for this type test is that the tube being tested, since it is part of the oscillator circuit, must be shielded from external conductors that might be stationary with respect to the moving tube. This requirement was ignored when tests were attempted on a planar gird tube. The resulting f-m was much greater than that normally resulting from interelectrode capacitance variation.

Measurement was made of the capacitance variation between each electrode and all of the other electrodes tied together except that the cathode and heater were tied together for cathode measurements. The latter technique was necessary because heater-cathode capacitance variation was much larger than any other interelectrode capacitance variation.

At the start of the tests, no heater voltage was used. Then heater-on versus heater-off tests were made. Only the vibration tests with the heaters on were used. There was a significant difference between the two conditions. Usually less interelectrode capacitance variation was observed with the heater on. It appeared that the cathode sleeve expanded sufficiently in the mica holes on heating to reduce cathode vibration.

No appreciable effect of heating on other electrodes was definitely established. By contrast, heater-cathode capacitance variation increased by as much as a factor of 10 when heater voltage was applied. Mechanical vibration resulting when a-c heater voltage is used causes a twice-frequency variation of heater-cathode capacitance of comparatively large proportions. A d-c heater supply was made standard, and a grid bias sufficient for cut-off was applied to prevent diode action.

Not enough of any one tube type was tested to give statistically satisfactory results (15 was the largest number of one type tested). However, each particular interelectrode capacitance variation measurement for each tube type showed distribution of peak values sufficient for a normal distribution estimate. There were expected variations between various electrode combinations and tube types.

The tube types tested were 5702, 5703, 6021, 6943, 6946, 6947, 6442 and 6BY4. Some tests were made on tubes with folded heaters rather than the more conventional coiled heaters. Only four of the folded-heater type were tested. They were found consistently bad with respect to heater-cathode capacitance variation, but quite good with respect to cathode-grid capacitance variation. Of the coiled-heater tubes the 6BY4 compared favorably to a transistor oscillator; the others were considerable poorer.

The 6943 guided missile tube (a pentode) had more capacitance variation between plate, screen, grid and cathode than other tubes tested. The variation showed up in the form of large resonant peaks

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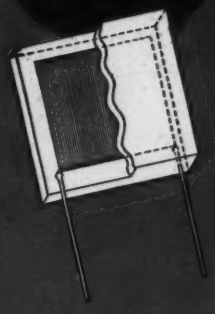

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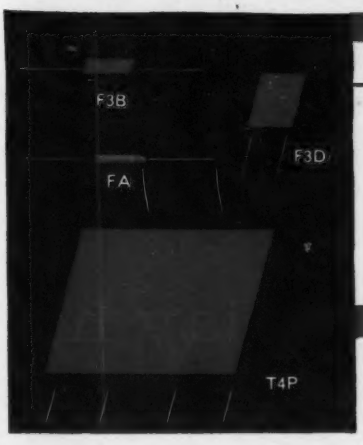

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0.25	3/4" x 3/16" x 1/2"	0.5-100,000	F3D
0.25	1" x 3/16" x 1/4"	0.5-100,000	H3B
0.5	1" x 3/16" x 3/8"	0.1-100,000	H3C
0.5	1" x 3/16" x 1/2"	0.1-200,000	H3D
0.75	1" x 3/16" x 3/4"	0.1-300,000	H3F
1.0	1" x 3/16" x 1"	0.1-400,000	H3H
1.5	1-1/2" x 3/16" x 1"	0.1-600,000	L3H
2.0	2" x 3/16" x 1"	0.1-1,000,000	P3H
Special	2-1/2" x 1/4" x 2"	0.1-2,500,000	T4P
TUBULAR			
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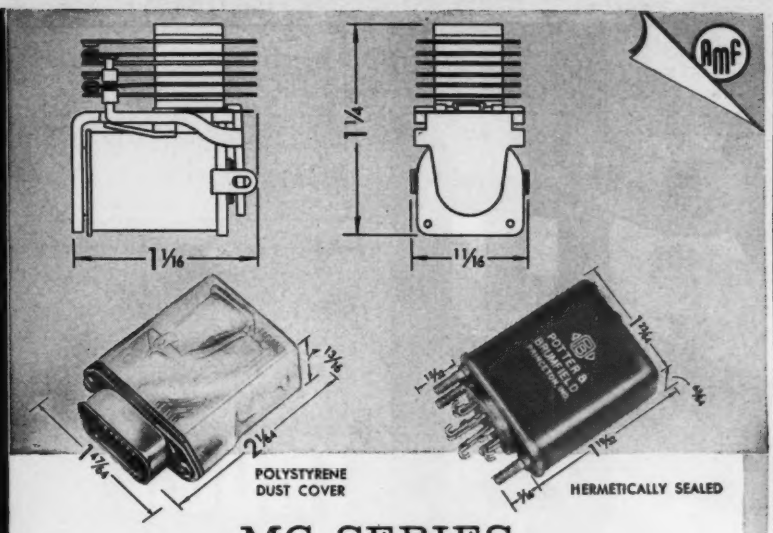

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in the 1,200 to 1,400-cps region. It appeared that a cantilever shield in the base of the tube had a resonance in this region, and its capacitive coupling to all other elements in the tube caused large variations for all elements. This effect did not show on normal vibration test data for this type tube.

Missile Antenna Design

By **HOWARD ESTEP**

Senior Research Engineer Convair
Division of General Dynamics Corporation
San Diego, California

GUIDANCE and telemetry systems require that missile antenna patterns be as nearly omnidirectional as possible so that contact be maintained with the ground stations no matter what attitude the missile assumes. Omnidirectivity is dependent upon the diameter in wavelengths of the missile.

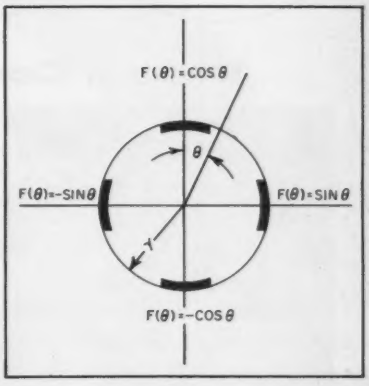

FIG. 1—Layout of omnidirectional missile antenna

Consider an antenna system comprised of 4 slots oriented with the slot perpendicular to the missile axis. In the plane perpendicular to this axis the radiation pattern of a slot may be represented as sin θ or cos θ (for r sufficiently large) as in Fig. 1.

If the slots are fed in phase with equal amplitudes, total radiation pattern becomes

$$E(\theta) = \text{Cos}\ \theta\ \text{Sin}\left(\frac{2\pi r}{\lambda}\ \text{Cos}\ \theta\right) + \text{Sin}\ \theta\ \text{Sin}\left(\frac{2\pi r}{\lambda}\ \text{Sin}\ \theta\right) \quad (1)$$

The mean value $\overline{E}$ of $E\ (\theta)$ *is*

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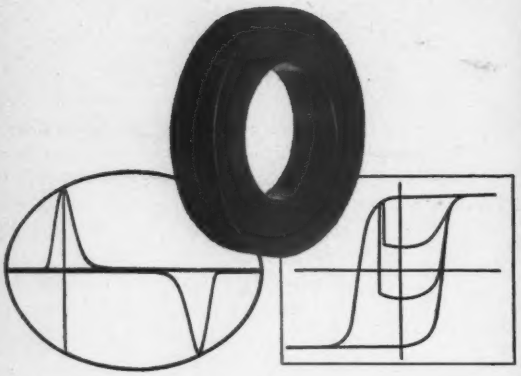

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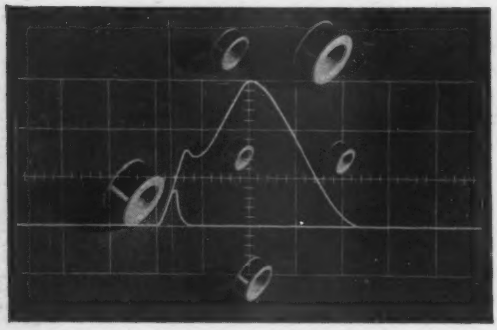

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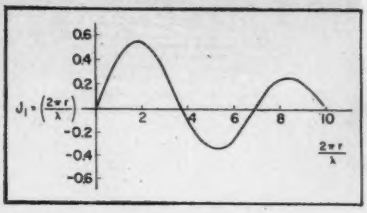

FIG. 2—Bessel function for first order

$$\overline{E} = \frac{1}{2\pi}\int_0^{2\pi} E(\theta)\, d\theta, \qquad (2)$$

by expanding $\sin\left(\frac{2\pi r}{\lambda}\cos\theta\right)$, $\sin\left(\frac{2\pi r}{\lambda}\sin\theta\right)$ into their Bessel identities.

$$\mathrm{Sin}\left(\frac{2\pi r}{\lambda}\,\mathrm{Sin}\,\theta\right) =$$

$$2\sum_{n=1}^{\infty} J_{2n-1}\left(\frac{2\pi r}{\lambda}\right)\mathrm{Sin}\,(2n-1)\theta \qquad (3A)$$

$$\mathrm{Sin}\left(\frac{2\pi r}{\lambda}\,\mathrm{Cos}\,\theta\right) =$$

$$2\sum_{n=1}^{\infty}(-1)^{n-1}J_{2n-1}\left(\frac{2\pi r}{\lambda}\right)\mathrm{Cos}\,(2n-1)\theta \qquad (3B)$$

Inserting this into Eq 2 and making use of the orthogonality relationships,

$$\int_0^{2\pi}\mathrm{Sin}\,n\theta\,\mathrm{Sin}\,m\theta\,d\theta = \left.\begin{matrix}0\\ \pi\end{matrix}\right\}\begin{matrix}m \neq n\\ m = n\end{matrix}$$

gives $\overline{E}$ (normalized) as

$$\overline{E} = J_1\left(\frac{2\pi r}{\lambda}\right),$$

as shown in Fig. 2.

Clearly $|E|$ is maximum when $\left|J_1\left(\frac{2\pi r}{\lambda}\right)\right|$ is maximum, or $\frac{2\pi r}{\lambda} =$ 5.5, 8.5, 10.6.

Figure 3 is a pattern resulting when $\frac{2\pi r}{\lambda}$ is such that $J_1\left(\frac{2\pi r}{\lambda}\right)$ is zero.

Figure 4 is the pattern obtained when $\frac{2\pi r}{\lambda}$ is such that $\left|J_1\left(\frac{2\pi r}{\lambda}\right)\right|$ is maximum. One should not assume that omnidirectivity is assured for all maxima of J_1 but rather the lobes will be broader under this condition than any other and hence, fewer elements will be required to achieve omnidirectivity. Perhaps the most important feature is that this criteria points out the values of r/λ to be avoided.

Referring to Fig. 1, the above treatment can be generalized by

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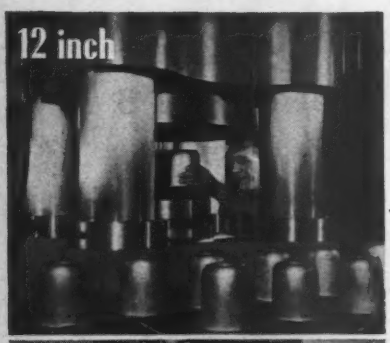

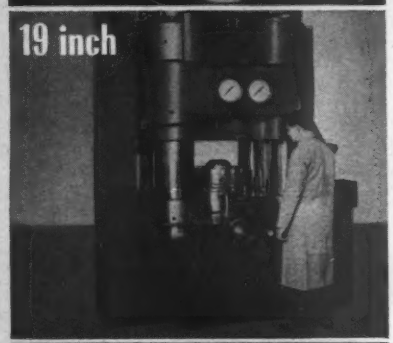

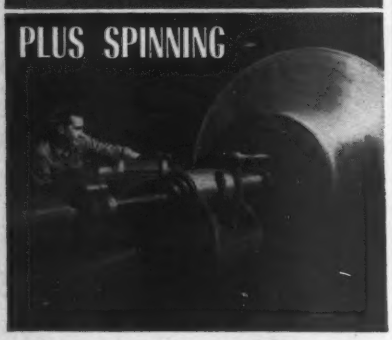

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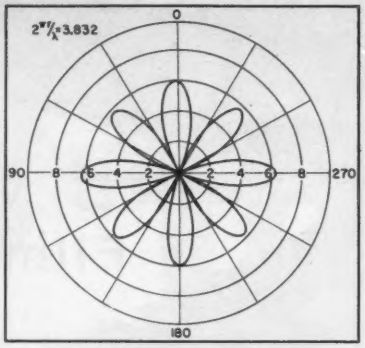

FIG. 3—Radiation pattern for J_1 $(2\pi r/\lambda)$ O

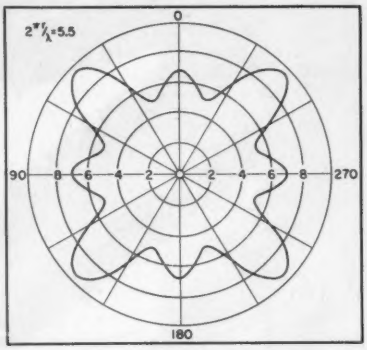

FIG. 4—Radiation pattern for J_1 $(2\pi r/\lambda)$ maximum

considering $f_1(\theta)$ as a Fourier series

$$F_1(\theta) = \sum_{n=1}^{\infty} a_n \operatorname{Cos} n\theta$$

and $f_2 = f_1(\theta - \pi/2)$. $\bar{E}$ becomes

$$\bar{E} = \frac{1}{2\alpha} \int_0^{2\pi} \sum_{n=1}^{\infty} a_n \operatorname{Cos} n\theta \operatorname{Sin}\left(\frac{2\pi r}{\alpha} \operatorname{Cos}\theta\right) d\theta + \frac{1}{2\pi} \int_0^{2\pi} \sum_{n=1}^{\infty} a_n \operatorname{Cos} n(\theta - \pi/2) \operatorname{Sin}\left(\frac{2\pi r}{\lambda} \operatorname{Sin}\theta\right) d\theta$$

which yields $\bar{E}$ to be an infinite series of Bessel functions. For most antennas having maximum radiation normal to the antenna aperture the predominate term of the Fourier representation will be cos θ (or sin θ, depending upon coordinates), and succeeding terms of the series of Bessel functions can be neglected thus arriving at the original result.

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DC Current Ranges (Full Scale)	±100μμa to ±100ma 10 ranges	None	±0.001μa to ±1ma 7 ranges	Not Applicable	±0.001μa to 1 amp 19 ranges
Input Impedance	10 megohms below 10mv– 30 megohms at 30mv– 100 megohms above 30mv	10 megohms below 10mv– 30 megohms at 30mv– 100 megohms above 30mv	10,000 ohms	Infinite at null	10 megohms at 30mv and below 100 megohms above 30mv
Measurement Accuracy	3%	3%	3% on 2 lower ranges, 4% above	0.02%	3%
Max. Output as Amplifier	1 volt across 1000 ohms	1 volt across 2000 ohms	1 volt across 1000 ohms	Not Applicable	1 volt across 500 ohms
Equiv. Input Drift (Max. Long Time)	10μv	15μv	<2μv	0.01% stability	10μv
Price	$550	$350	$325	$625	$550

*The 301 utilizes a null voltmeter to indicate difference between voltage being measured and output of its variable DC supply. Its null meter has 4 full scale ranges from ±0.05 to ±50 V.

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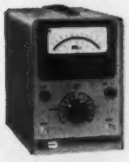
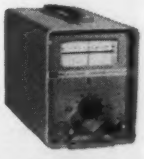


Model 202B. Wide range, DC microvoltmeter-amplifier. Zero center meter gives instant polarity indication.



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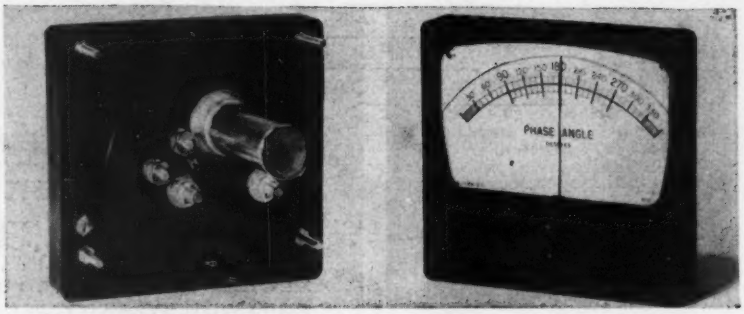

Nylon headed plunger pushes against the back of the face plate and clamps the pointer in position at the reading instant

The unit, developed by Assembly Products Inc, Chesterland, Ohio is essentially a sensitive panel meter with a rear-mounted solenoid and plunger. The solenoid is normally energized and the plunger retracted. When a reading is desired, the solenoid is de-energized. A nylon-headed plunger pushes against the back of the face plate, which is normally held away from the pointer by two small springs at its base. At the reading instant the pointer is held fast between the face plate and a clamper plate mounted over the top arc of the face plate.

The memory meter is available in almost any sensitivity range, from a few μa or mv to 50 amp or 500 v either d-c or a-c. In present models, the solenoid coil operates on 100 d-c and about 30 ma. An external rectifier may be used with a-c current.

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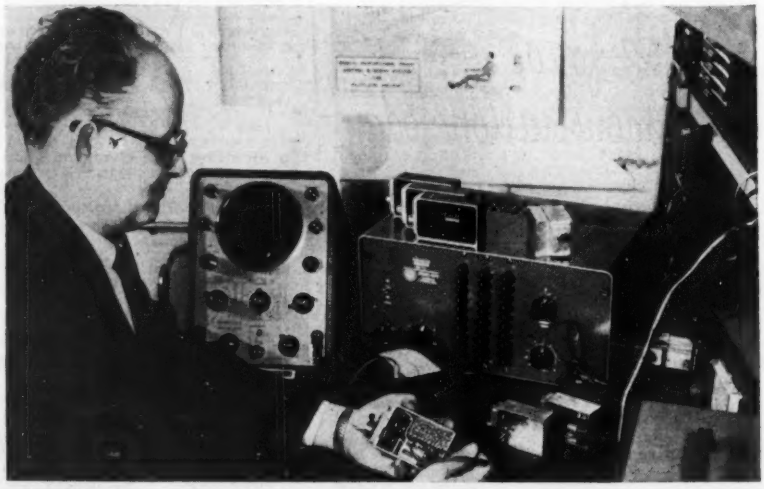
A DIODE NETWORK which compensates for ambient and junction temperature changes permits transistors to be used in medium and high power servomechanism. Compensating for transistor amplifier drift has been attempted through the use of resistors, but this method simply restricts the operating range of the transistor and the drift current is still present and uncompensated. The transistor amplifiers in the servomechanism use diodes for temperature compensation. Output power up to 140 w is obtained from the amplifier with negligible drift.

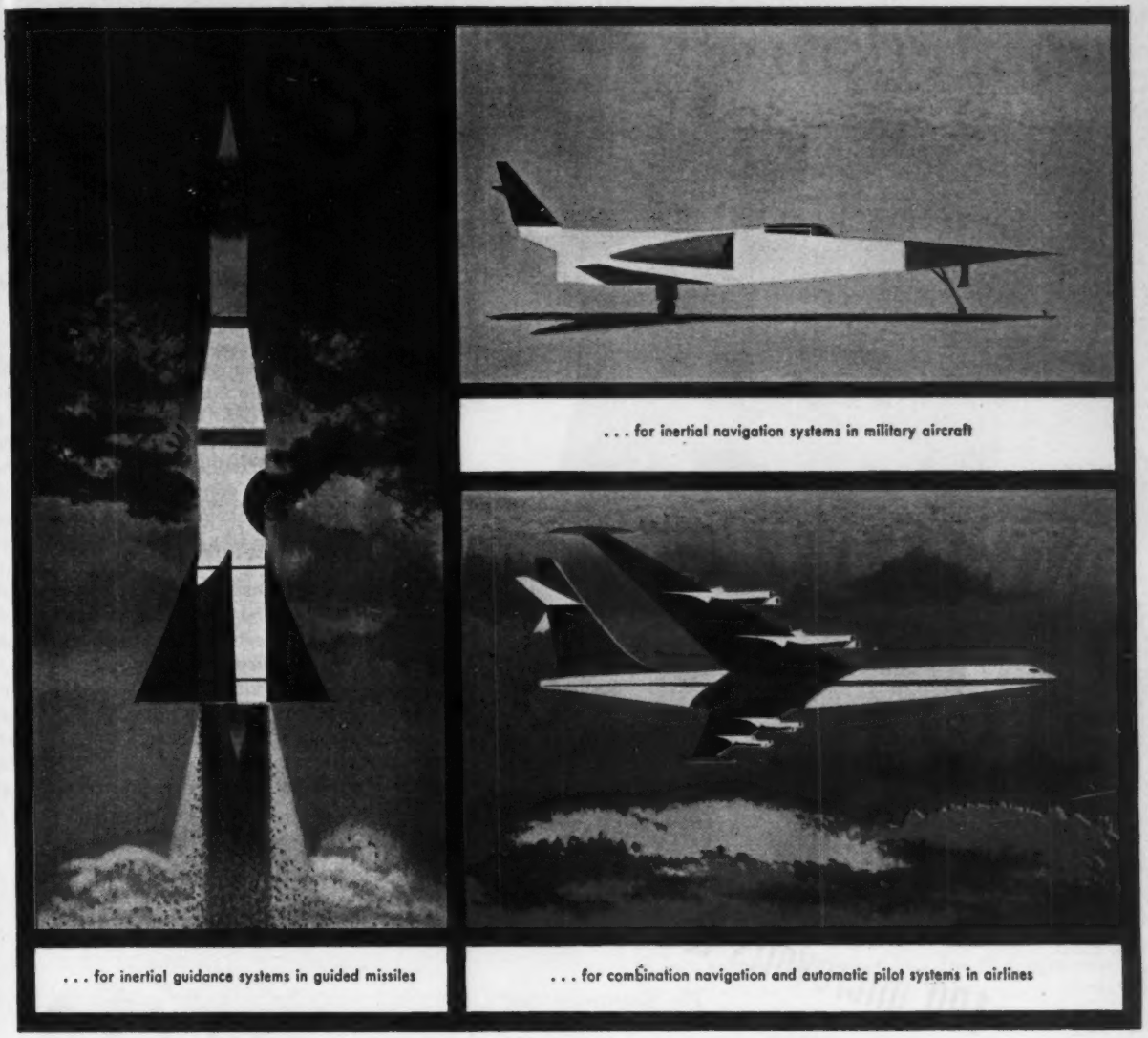
The temperature compensating network was designed by Advanced Research Associates Inc, 4128B Howard Ave., Kensington, Md. for use in their model 2-ARA d-c servomechanism. The units have high speed and high torque characteristics and are packaged in a small size currently found only in low power instrument type servos.

The electronic portion of the servo uses transistors with the exception of the input stage. A vacuum tube is used at the input to convert the signal voltage to a current through transconductance. In this way the component best suited to the job is used. The input signal voltage sees a grid and the output current sees the transistor amplifier. A vacuum tube input also permits use of the servo as a replacement or complement to larger or less efficient high impedance existing systems.

The transistors are temperature stabilized with a diode connected between the base and emitter. The diode used has several special characteristics and in addition must have the correct thermal connec-



Measuring response characteristics of servo amplifier



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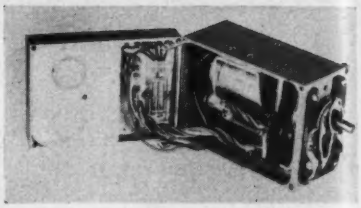

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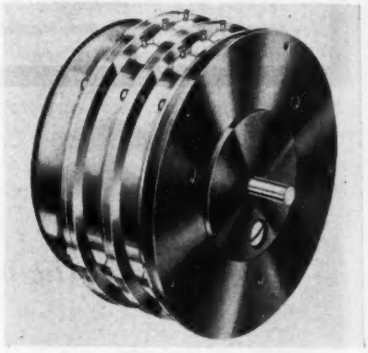

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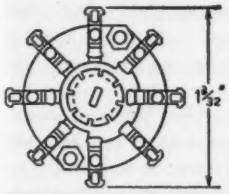

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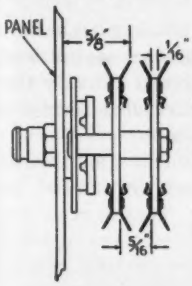

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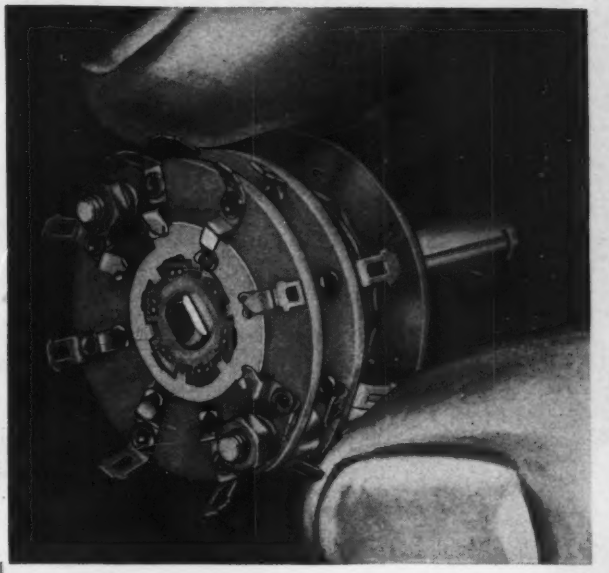

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- SAME HIGH QUALITY AND RELIABILITY AS LARGER OAK SWITCHES

Here's new help in the battle of miniaturization. This tiny switch can pare critical space and weight from your designs. The large number of contacts it provides enables you to handle complex circuits, too. The clips on the Series "A" are a miniature version of the famous Oak double-wiping design—long accepted as the standard of the industry for reliability and long life. Oak engineers will be glad to furnish complete information, and work with you in developing the exact variation you need.

Write on Company Letterhead for a Copy of the Oak Switch Catalog

SPECIFICATIONS

Index—Double ball bearing, hill and valley type with stainless steel spring. Fixed and adjustable stops, and locating key available.

Shafts and Bushings—1/4" shaft with 3/8-32 bushing is standard; 5/32" shaft with 3/8-32 bushing and 1/8" shaft with 1/4-32 bushing can be supplied also. Water seal bushings optional.

Sections—8, 10, or 12-position, stacked in any number up to a total depth of three inches. The 12-position section provides up to 18 insulated contacts—12 on front, 6 on back. *No insulating blocks are needed on back.*

Poles	8-Position (45° throw)	10-Position (36° throw)	12-Position (30° throw)
1 pole	2 to 8	2 to 10	2 to 12
2 poles	2 to 4	2 to 5	2 to 6
3 poles	2 to 3	2 to 4	2 to 5
4 poles	2	2 to 3	2 to 3
5 poles	. . .	2	2
6 poles	. . .	. . .	2

Clips—Solid spring-silver alloy or silver-plated spring brass, fastened by solid rivets.

Insulation—Stator is silicone fiber glass, meeting specification MIL-P-997 type GSG; rotor is KEL-F®, known for its excellent mechanical and electrical properties.

Finish—Commercial or 50 and 200-hour salt spray.

OAK MFG. CO.

1260 Clybourn Avenue, Dept. G, Chicago 10, Illinois
Phone: MOhawk 4-2222

SWITCHES • ROTARY SOLENOIDS • CHOPPERS • SPECIAL ASSEMBLIES • VIBRATORS • TUNERS

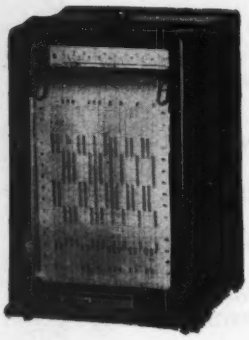
Costs Going Up?
Production Down?

ESTERLINE-ANGUS
OPERATION RECORDERS
Will Show You Why

20 Pens in a single recorder will monitor 20 machines or events. Available for

DC: 2-250 Volts

AC: 6-240 Volts



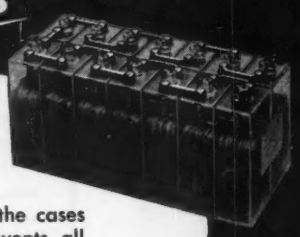
Ask for Catalog Section 50

Product Representatives in Most Principal Cities

The ESTERLINE-ANGUS Company, Inc.
Pioneers in the Manufacture of Graphic Instruments
DEPT. E10, P. O. BOX 596, INDIANAPOLIS 6, INDIANA

CIRCLE 175 READERS SERVICE CARD

STURGES BATTERIES



NON-SPILL IN ANY POSITION!!

The molded plastic cases, in which Sturges batteries are assembled, are completely seamless. The covers are firmly cemented to the cases and a special baffle and non-spill vent prevents all capillary or creeping action of the electrolyte . . . permitting the emission of only dry harmless gas from the cells.

Type "H" Storage Battery Amp. Hrs. —15 Voltages from 2 to 28 or as specified Weight from 1⅞ lbs. to 26½ lbs.

Type "S" Storage Battery Amp. Hrs.—6, Voltages from 2 to 28 or as specified. Weight from 12 oz. to 12 lbs.

FREE
Write for literature on six different sizes of type "S" and type "H" Batteries, including performance curves, size specifications, etc.

CONSULT US ON ALL YOUR SPECIAL BATTERY APPLICATION PROBLEMS

★ Lightweight—Non-Spill (in any position)
★ Transparent Molded Plastic Case
★ High Output of Watt Hours Per Pound of Battery
★ Continuous High Voltage Uniformity While Discharging
★ Conforms to Any Amount of Space

STURGES BATTERIES

manufactured by ELECTRONIC BATTERIES, INC.
Bush Terminal Building Number 4 • 28-34 35th Street • Brooklyn 32, New York

claimed over conventional models.

Liquid filled pots were developed by Helipot Corp., New Beach, Calif. to free potentiometer sensitivity from environmental influence. From the very instant of application in a working system—and often before—a potentiometer begins to deteriorate. Wear products, moisture, electrical potential, and heat all contribute to deterioration within the housing of a potentiometer.

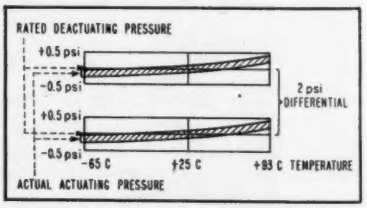
Engineers at Helipot reasoned that a potentiometer sealed and running in oil should provide the greatest possible freedom from environmental influence.

Three liquid-filled, multi-turn versions have been introduced as standard models. These are a 10-turn 1⅛ in. diameter potentiometer for bushing mounting plus 3-turn and 10-turn 2 in. diameter models for servo mounting. Prototypes now in final development include 2 and 3 in. diameter, single-turn potentiometers.

Switch Withstands 7 G's at 1,000 Cps

Developed for use under vibration, shock and acceleration the model RR-30 sub-miniature absolute air pressure switch is accurate to plus or minus 0.5 psi from −85 F to 200 F. Pressure difference between the *on* and *off* points is 2 psi. An important design feature is that the switch will not chatter at the operating points.

The sensing mechanism in the RR-30 switch developed by Newark Controls Co., 15 Ward St., Bloomfield, N. J., is a hermetically sealed evacuated bellows. Air pressure being sensed enters through the pressure port. As the pressure

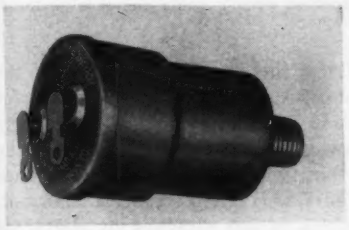


Relative change in operating pressure over −65 C to +93 C temperature range

changes the bellows which is similar to a covered helical spring contracts or expands linearly. The face or end of the bellows works against the actuating pin of the electrical switch turning it *on* and *off* at the pressure settings.

Vibration

The maximum pressure error of the switch due to vibration is 0.3 pounds per square inch. This vibration Error lowers the actuating pressure 0.3 psi and raises the deactuating pressure 0.3 psi, therefore under the worst vibration conditions the differential between the *on* and *off* pressures is reduced from 2 psi to 1.4 psi.



Miniature pressure switch does not chatter under vibration

The pressure switch is suited for use on aircraft, missiles, parachutes, balloons, wave-guides or vibrating equipment. It comes in nominal pressure settings from 5½ psi to 23½ psi.

SPST, open or close on decreasing pressure or SPDT switches are available.

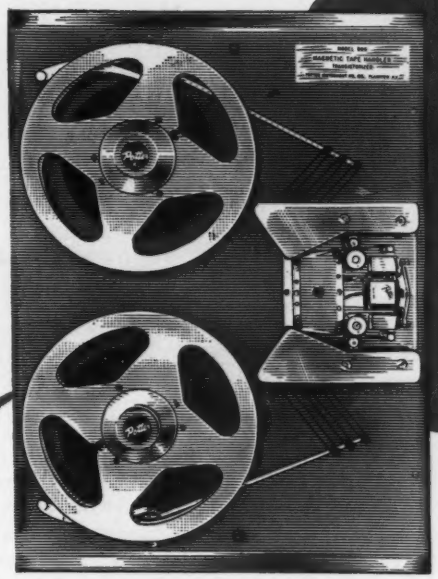
Overall length is 2$\frac{3}{32}$ in. and weight is 2 oz.

Full scale rotation is 56 deg. Resonant frequency is 9 cps and the damping coefficient is 0.4 to 0.6. Input impedance is 1 meg. and power input is 28 v d-c center tapped. Free running speed is 180 deg/sec. and maximum operating temperature 75 C.

Applications

The original design has been adapted to applications requiring much higher load torque capabilities. To date both ten and twenty-five foot/pound units of comparable characteristics have been developed for special applications, with units of several hundred foot/pounds currently in the design stage.

New...from Potter



No. 1 source of peripheral equipment for digital computers

MODEL 906

Transistorized Digital Magnetic Tape Handler

Replaceable Capstan Panel permits use as Perforated Tape Reader with a remarkable new brake capable of stopping on the stop character at speeds up to 1000 characters per second.

NEW SPEED • VERSATILITY • RELIABILITY

The advanced design of the completely transistorized Potter Model 906 Tape Handler provides improved performance in virtually any tape handling application. Using a small vacuum loop buffer, Model 906 features:

- Complete front accessibility—single panel construction
- Pinch rollers capable of 100 million start-stop operations
- In-line threading, end of tape sensing and tape break protection
- Speeds up to 150 ips
- As many as 4 speeds forward and reverse
- Capable of continuous cycling at any frequency from 0 to 200 cps without flutter
- Rewind or search at 400 ips
- 3 millisecond starts
- 1.5 millisecond stops
- Tape widths to 1-1/4"
- Up to 47 channels
- All functions remotely controllable

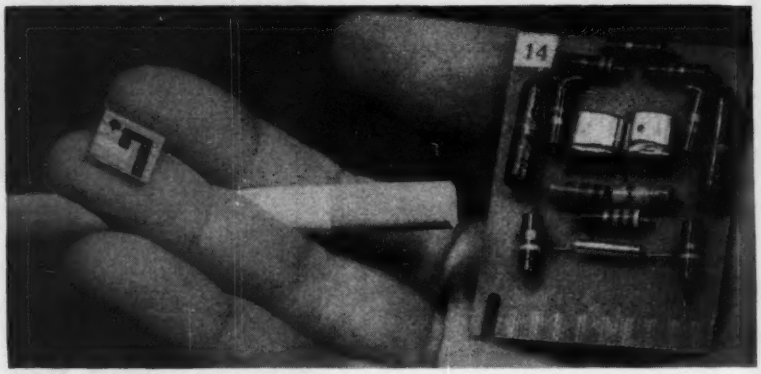
The 906 may be supplied with completely transistorized Record-Playback amplifiers featuring electronic switching from record to playback function, with separate module for each channel.

Other Potter products include Transistorized Frequency Time Counters, Magnetic Tape Handlers, Perforated Tape Readers, High Speed Printers, Record-Playback Amplifiers and Record-Playback Heads.

POTTER INSTRUMENT COMPANY, INC.
SUNNYSIDE BOULEVARD, PLAINVIEW, N. Y.
OVERBROOK 1-3200

Transistors Are Made By Photolithography

By J. R. Nall and J. W. Lathrop
Diamond Ordnance Fuze Laboratories
Washington, D. C.



Transistor is dot in upper left corner of fingertip-sized circuit. Entire circuit is no larger than transformer now used in circuit at right

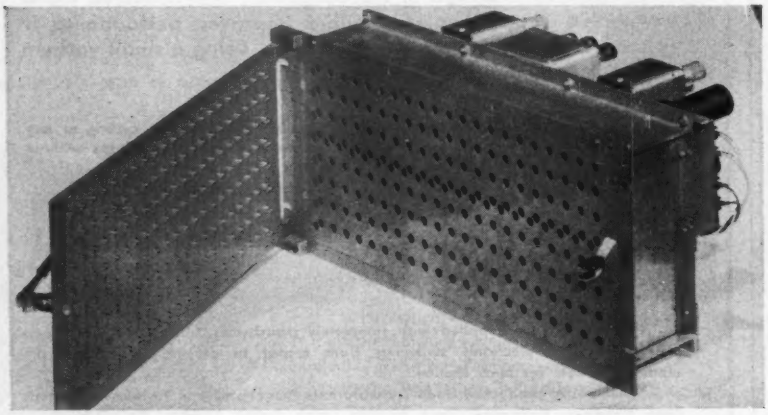
Photolithographic techniques allow great flexibility of miniature transistor design, evaporation of leads and produce a transistor that is an integral part of the printed circuit and able to withstand high shock.

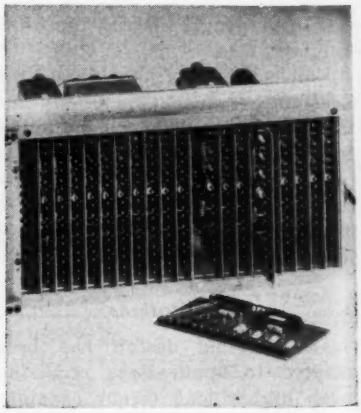
Diffused blanks 0.045 inches by 0.045 inches by 0.010 inches are used. The original material is p-type about 1 ohm-cm into which arsenic is diffused giving rise to an n-type skin about 9 μ thick. The p-type material becomes the collector of the finished transistor and the n-type skin the base. A layer of photosensitive resist is placed on the germanium surface, masked, exposed and developed leaving a bare rectangular area of germanium.

The aluminum emitter material is evaporated and deposited over the layer of resist. When the underlying resist is chemically stripped away the aluminum remains only on the rectangular area. Resolution equivalent to mechanical masking can be achieved by this process. After the aluminum emitter is alloyed to the germanium by heating, a base contact pattern of similar shape is formed next to the emitter by the same photolithographic process. The contact is electrolytically deposited gold with a small percentage of antimony.

The gold is deposited on clean germanium surface and resist is not stripped before alloying. The gold alloys at a lower temperature than the aluminum, leaving the emitter undisturbed. The collector base junction is defined by etching away the n-type skin except in the vicinity of the emitter and base contacts. Photosensitive lacquer, which is not attacked by the acids commonly used to etch germanium, controls the pedestal geometry during etching. The transistor is soldered to a thin base plate and inserted into a hole in a ceramic printed circuit board. Any

DESIGN TRENDS: Card Programs Function Generator





Diode function generator designed by Electrol, Inc., Los Angeles, Calif., for analog computer rack-mounting, employs punched cards. Cards allow pre-programming to reduce setup time, act as function memory or permanent record. Card is placed behind front door. As door closes, spring-loaded plungers in door pass through card holes, actuating sealed switches. Switches, the only moving parts in circuits, set up resistor networks to perform the function. Functions may be composed of 20 contiguous line segments, each with slope values from 0.01 to 10.16 v/v. Zero offset, slope and scale factor are programmed on same card. Plug-in resistor assemblies may be varied to change break points. Accuracy is stated as 0.1 per cent. Photo at left is front with door open to show plungers and plate which backs up card. At right, plate is removed to expose function networks

first of the new

SANBORN 450's:

UNIT PREAMPLIFIERS

with Integral Power Supplies

These new Sanborn Unit Preamplifiers—designed to drive optical recording systems, tape recorders, wide band oscilloscopes, panel meters and other devices—offer you an outstanding combination of performance characteristics, operating versatility and ease, flexibility through interchangeable design, and compactness in either single unit or four-unit rack module packaging. The 1100 Carrier and 1800A True Differential DC types are versatile enough to cover the vast majority of input signal requirements, with practically any type of transducer. (For use with high speed optical galvanometers at frequencies above 500 cps, requiring larger current swings, a transistor output amplifier is built into the 450-1800A and available as optional equipment on other 450's.) Later "450" Unit Preamplifiers will include Servo (demodulator) Monitor, DC Coupling, Logarithmic, Low Level and Dual-Channel DC types. As shown, any "450" can be installed or quickly interchanged in any bay of the four-Preamp module, or in a portable case.

Supplementing the basic specifications, the 450-1100 is a carrier amplifier-demodulator with zero suppression, which provides excitation for and accepts the outputs of various resistance bridge, variable reluctance, differential transformer and other types of transducers. The 450-1800A is a low-noise, low drift, wide band-width, high gain true differential DC amplifier, with front panel controls for smooth gain, position, and internal 2 mv calibration signal. For further data or application information on these new self-contained Unit Preamplifiers, contact your Sanborn Industrial Engineering Representative or write the Industrial Division of Sanborn Company.

SANBORN COMPANY

175 Wyman St., Waltham 54, Mass.

SPECIFICATION SUMMARY

MODEL 450-1800A TRUE DIFFERENTIAL DC PREAMPLIFIER

Input — Impedance: 200K differentially between terminals (balanced) or 100K each input lead to gnd. (single-ended)
Common mode rejection: at DC, 100 db; to 60 cps, 94 db; 400 cps, 80 db.
Equiv. input drift: ±2 uv for 24 hours
Equiv. input noise: 5 uv peak to peak (0–10 cps), 20 uv (0–1000 cps), 50 uv (0–30 kc)

Output — Low Power Circuit:
Output appears between two cathodes as true push pull signal.
Common mode level of cathodes ±.2 volts with respect to ground.
Output capability: ±3 volts into 5000 ohms
±10 volts open circuit
Zero position control *not* active for this output
Freq. response; 3 db down at 30 kc
Linearity: 0.1%
High Power Circuit:
Output appears between two emitters as true push pull signal.
Common mode level of emitters ±2.5 volts with respect to ground.
Preferred load: 50 ohms
Output: ±2.5 volts, ±50 ma
Freq. response; 3 db down at 15 kc
Linearity: 0.5%
Zero position control is operative for high power output ckt.

Gain — Fixed steps 1000, 500, 200, 100, 50, 20
Gain Accuracy 0.5% for D.C.
Smooth gain control covers range between fixed steps

Power Req. — 115 volts, 60 cps, approx. 50 watts

MODEL 450-1100 CARRIER PREAMPLIFIER

Carrier Freq. — 2400 cps (std.); 600, 1200, 4800 cps optional

Carrier Exc. — approx. 4.5–5 volts, depending on transducer imped.

Transducer Imped. — 100 ohms min. - 1000 ohms max.

Input Imped. — approx. 2500 ohms, incl. zero sup. ckt.

Sensitivity — 100 uv rms from transducer (output imped. 1000 ohms or less) gives 1 volt at output under max. output loading

Output — preferred circuit: between one active cathode and one reference cathode
alternate circuit: between active cathode and ground

Output Voltage Capabilities — (a) ±3 volts into 2.2K min. load
(b) ±6 volts into 5K load
(c) ±7.5 volts open ckt

Output Linearity — better than 0.2% for (a) above

Output Impedance — approx. 1000 ohms, preferred ckt., 500 ohms alternate output ckt.

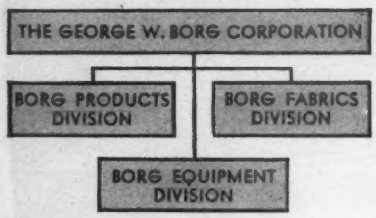
Freq. Response — 3db at 20% of carrier freq.

Zero Suppression — can suppress 0 to 100% of transducer load (either sense via switch)

Power Req. — 115 volts, 50–400 cps, approx. 30 watts

WHO IS BORG?

George W. Borg, who founded this corporation, is the "Mr. Clutch" who started with Borg & Beck. He then helped organize the Borg-Warner Corporation of which he became president. Later he served as chairman of the board until he resigned to devote his full attention to The George W. Borg Corporation.



The George W. Borg Corporation is comprised of three divisions

- **Borg Products Division**
  Manufactures automotive clocks.
- **Borg Fabrics Division**
  Manufactures deep-pile fabrics best known of this line is the fashionable "Borgana" fabric.
- **Borg Equipment Division**
  Manufactures Micropots (precision potentiometers), Microdials (precision turn-counting dials), instrument motors, frequency standards, aircraft navigational instruments and components for systems.

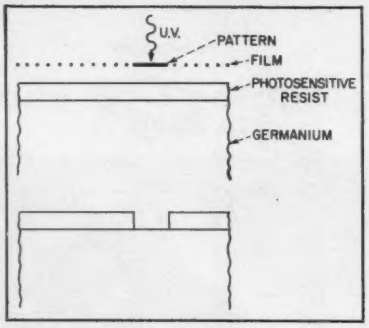
HOW BORG EQUIPMENT DIVISION CAN HELP YOU . . .

Borg's background of experience will save you time and money by helping you solve design and production problems of electronic components. Whether you are faced with a special problem or interested in a standard component, call Borg Equipment Division for an economically sound solution. Write today for catalog BED-A56.

BORG — Built by Borg
MOTORS
MICROPOTS
MICRODIALS

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

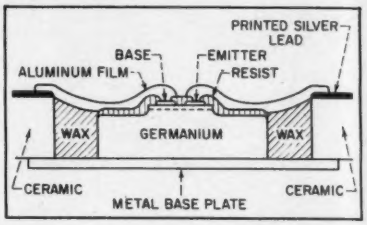
CIRCLE 65 READERS SERVICE CARD



Schematic diagram of exposure process for germanium blanks

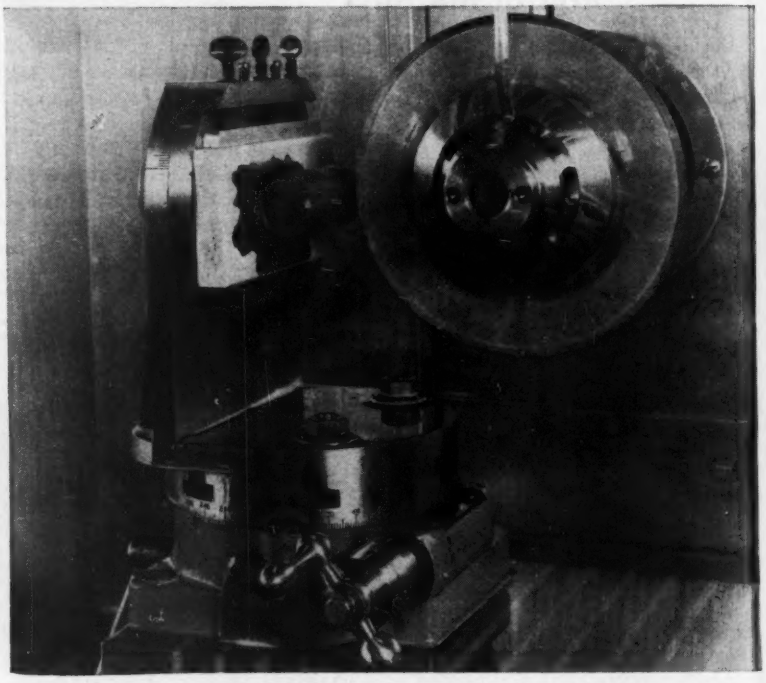
gap between the board and the die is filled with insulating cement which serves to firmly attach the transistor. By using relatively crude masking, aluminum leads may now be vacuum deposited for connecting the printed wiring on the board with the contacts in the pedestal. The leads have a conductivity approximately equivalent to a wire 0.0006" in diameter.

The photo resist insulates the deposited leads from the germanium surface and protects the surface from contamination until the entire circuit or combination of circuits can be hermetically sealed.



Cross section shows finished transistor fixed in hole in ceramic printed circuit board. Final aluminum film makes leads

Flanges Feed Cutting Coolant



Flanges on 5 inch diamond wheel are slotted to permit coolant to flow into cut by centrifugal force. Crystal holding fixture shown permits cuts along any desired plane

COOLANT FEED flanges are employed in semiconductor wafering machines made by Micromech Mfg. Corp., Union, N. J. The technique helps prolong the life of metal bonded diamond wafering wheels.

The flanges, which impart rigidity to the wheel, are machined so that they also feed coolant along the surface of the wheel into the kerf.

The coolant is fed under pressure through tubes into a radial groove in the flanges. A portion of the cool-

Pair of flanges. Inside is hollowed to accomodate flow of coolant into feeding slots from radial groove on exterior

ant flows through slots to the hollowed inside of the flanges. Centrifugal force carries the liquid out through slots and along the wheel surface.

Flanges are made of 303 stainless steel. They are first roughed turned, faced and the radial groove and hollow undercut made. Then they are drilled and reamed to exact bore, all on a lathe.

The through slots are located in a dividing head and drilled. The flanges, still mounted in the dividing head, are transferred to a vertical milling machine for through slot milling.

The flanges are returned to a lathe, mounted on a mandrel between centers and a finish cut taken all over. Radial runout is held to 0.0005 inch and parallelism of faces, to 0.0001 inch. The diameter of the flange will depend on the depth of cut desired.

Casting Brushes in Continuous Strips

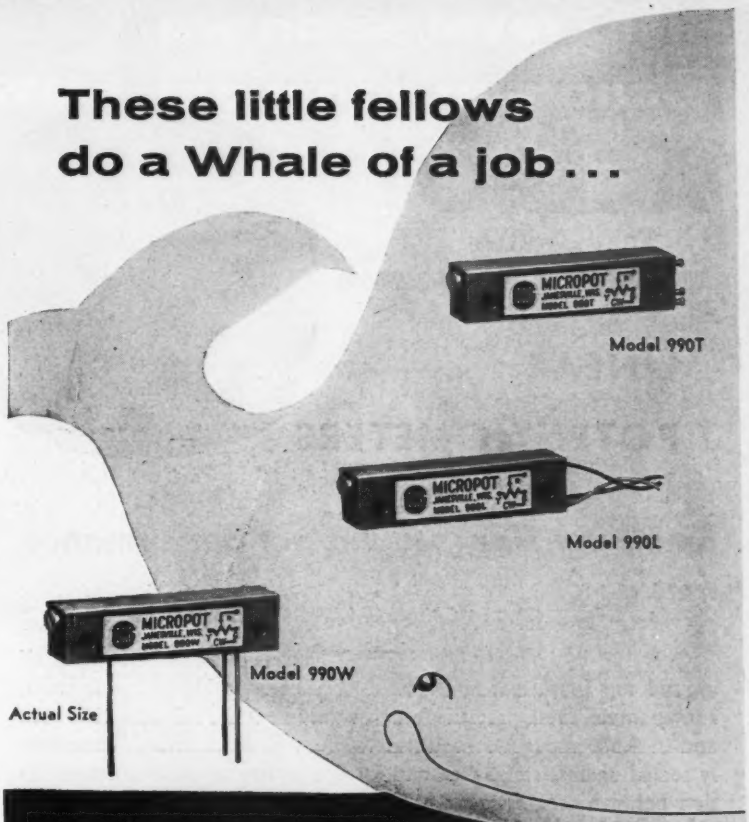
By E. Natkins
Chief Engineer
Gries Reproducer Corp.
New Rochelle, N. Y.

REDESIGN of the five-piece brush assembly for an impulse counter permitted production as one piece by Gries, with resulting improvements in counter assembly time, operation and cost.

IBM uses 18,000 counters of this type yearly in its model 101 statistical machine, model 9600 automatic production recorder and model 528 accumulating reproducer.

Except for bending of brush tips and packaging, automatic machines are used. First, strands of 0.008

These little fellows do a Whale of a job...



BORG TRIMMING MICROPOTS

Borg 990 Series Trimming Micropots provide accurate voltage adjustments in critical electronic circuits. Extremely small, they fit readily into subminiature circuits. They are wire wound and adjustable. Borg Trimming Micropots are protected against humidity, salt-spray, dust and other adverse environmental conditions. They can be mounted individually or stacked to give the designer the greatest possible latitude. Borg 990 Series Trimming Micropots are available with three types of terminals . . . printed circuit, soldered lug and insulated wire leads.

Write today for the name of your nearest Borg "Tech-Rep." It will pay you to know him.

Write For Complete Information . . .
Bulletin BED-A66

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

ELECTRONIC – MECHANICAL BORG EQUIPMENT Built by Borg

MOTORS
MICROPOTS
MICRODIALS

ACEPOT®

SUB-MINIATURE, PRECISION, WIRE-WOUND

LINEAR POTENTIOMETERS

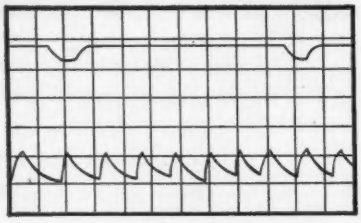
500 Series ACEPOT actual size

Small pot size — Big pot performance

Only ½" in diameter, the ACEPOT excels in a combination of all around top performance characteristics comparable to larger units. For example, these precision units feature ± 2% resistance tolerance and ± 0.3% independent linearity. Every potentiometer is completely sealed against sand, dust and foreign matter to avoid abrasive action between moving parts. All materials and metals are treated for maximum resistance to salt spray, corrosion, humidity and conform to shock and vibration tests. ACEPOTS are designed and assembled MIL-A-8625A, QQ-M-1512, JAN-T-152, MIL-E-5272A, MIL-R-19A, NAS-710 and MIL-R-19518 (ships).

ACEPOT LINEARITY TEST

Plot of voltage ratio error versus rotation illustrates linearity to better than ± 0.3%.



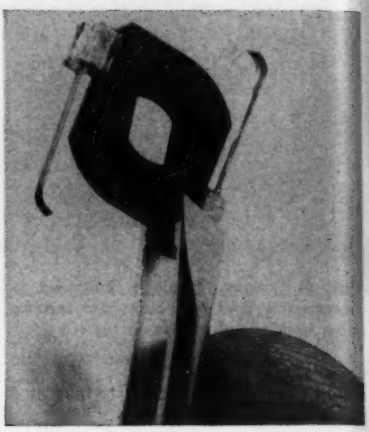
ACEPOT RESOLUTION TEST

Section of oscillograph trace of electrical resolution shows voltage change for each turn of wire.

ACE offers a wide variety of linear and nonlinear precision, wirewound potentiometers in standard, special and AIA sizes. Custom designs to meet special requirements can be made available on short lead time. Call, write or teletype Dept. F, ACE ELECTRONICS ASSOCIATES, INC., 99 Dover Street, Somerville, Mass., SOmerset 6-5130, TWX SMVL-181.

ACEPOT® ACETRIM® ACESET® ACEOHM®

ACE ELECTRONICS ASSOCIATES, INC.

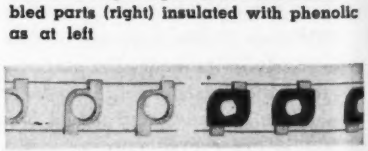


Impulse counter brush assembly using music wire, zinc and nylon emerges in one piece from casting and molding machines

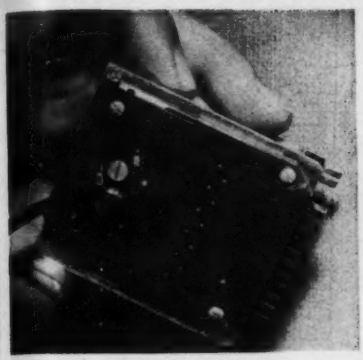
music wire, 3 on a side, are spaced and aligned. Zinc alloy is die-cast around the strands, bridging them at the proper interval and making a continuous chain of cores. The strand and bridge unit becomes the insert for the molding operation, which is handled exactly like an insert casting. Black nylon is molded around the bridge, leaving only a small ear of zinc exposed on each side. The wire may be bent later to center the spring wire strands on the counter contact points. The ends of the strands are cut and bent to specification.

The brush and insert assemblies are die-cast and molded one at a time. Each part is certain to be within tolerance and any variation

Former design required five hand-assembled parts (right) insulated with phenolic as at left



Cast zinc cores, bare at left and insulated with black nylon at right, are shown before spring wire brushes are cut and bent



Notched tool bends ears of brush unit to center brushes on contacts in assembled impulse counter

Brush tips are passed under gas flame and air jet (top center) in hardening machine after brushes are loaded into recesses on rim of vertical wheel

within specifications is the same from one part to the next so all parts fit equally well. Die changes may be made quickly.

The ends of the wire are hardened about $\frac{1}{32}$ inch to improve service life. Tips of the completed brushes are passed under a gas flame and quenched by blasts of cold compressed air. The final operation is bending the strands outward to achieve slightly higher spring pressure when inserted into the readout.

The counter is run in for 6 hours at 360 rpm. This is followed by two hours of testing at 48 v, at 20 impulses per minute and 480 rpm, followed by below-normal voltage tests, 30 v at 240 rpm.

Low noise level
Wide frequency response
High input impedance

MODEL 310A
Price $235

...with this BALLANTINE Sensitive Electronic Voltmeter

To measure	40 microvolts to 100 volts
from	10 cycles to 2 megacycles
with accuracy (>100 μv)	3% to 1 mc; 5% above
Shorted input noise	less than 20 microvolts
Input impedance	2 megohms shunted by 19 mmfd below 10 mv; and by 9 mmfd above

Usable as null detector sensitive to 10 μv from 5 cps to 4 mc

NOTE THE MANY USES OF THIS BALLANTINE VOLTMETER:

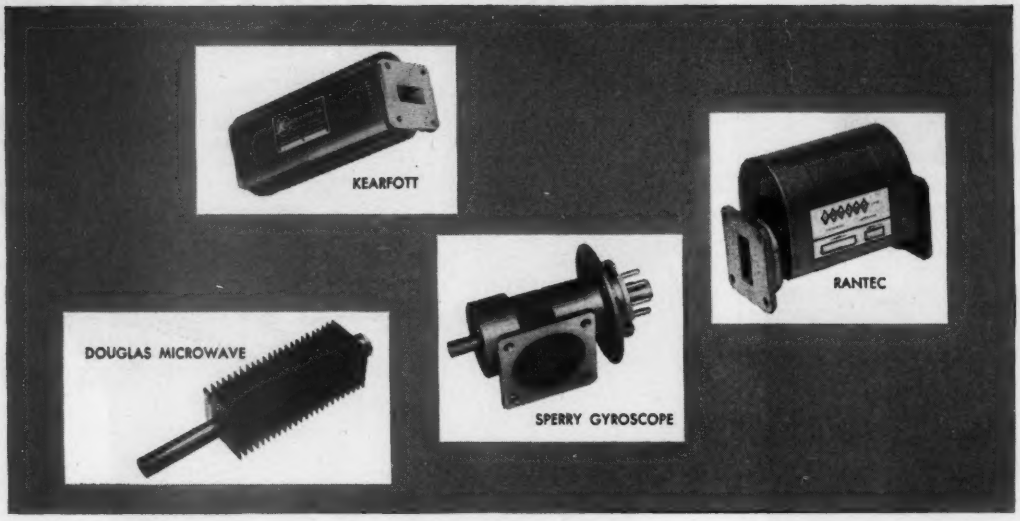
- Acoustic measurements
- Low level vibration measurements
- Audio amplifier tests
- Carrier telephone transmission
- Ultrasonic development
- AM broadcast band signal measurements

Write for catalog for more information about this and other BALLANTINE voltmeters, amplifiers, and accessories.

BALLANTINE LABORATORIES, INC.

100 Fanny Road, Boonton, New Jersey

Microwaves Spur New Parts



Loads, Isolators Included

MICROWAVE systems continue to be a vital segment of the electronics industry. Versatility of the systems depends largely on equipment used. New equipment designs, in turn, rely on availability of new microwave components.

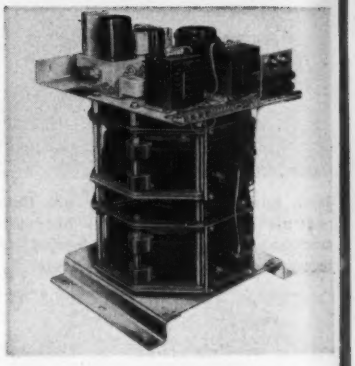
Kearfott Co., Inc., 14844 Oxnard St., Van Nuys, Calif., (275), has come out with model W177-5C1 transverse field ferrite isolator which operates over the frequency range of 8.2 to 12.4 kmc and is capable of handling an average power of 100 w. Isolation is indicated at 20 db minimum and insertion loss is only 1.3 db maximum over the entire range.

A complete line of very high power loads in both coaxial line and waveguide is announced by **Douglas Microwave Co., Inc.,** 252 E. Third St., Mt. Vernon, N. Y., (276). Recent exhaustive tests reveal these loads will take more than 75 percent of the full power capabilities of the line size used.

Rantec Corp., P. O. Box 18, Calabasas, Calif., (277), has added to its ferrite line the BX8121 load isolator. It utilizes the principle of resonant absorption of microwave energy. The unit is constructed with RG-52/U waveguide and covers the entire useful X-band frequency range from 8.2 to 12.4 kmc. It is 3.5 in. long, light-weight, rugged, and has a typical isolation of 20 db with an insertion loss of 1.0 db.

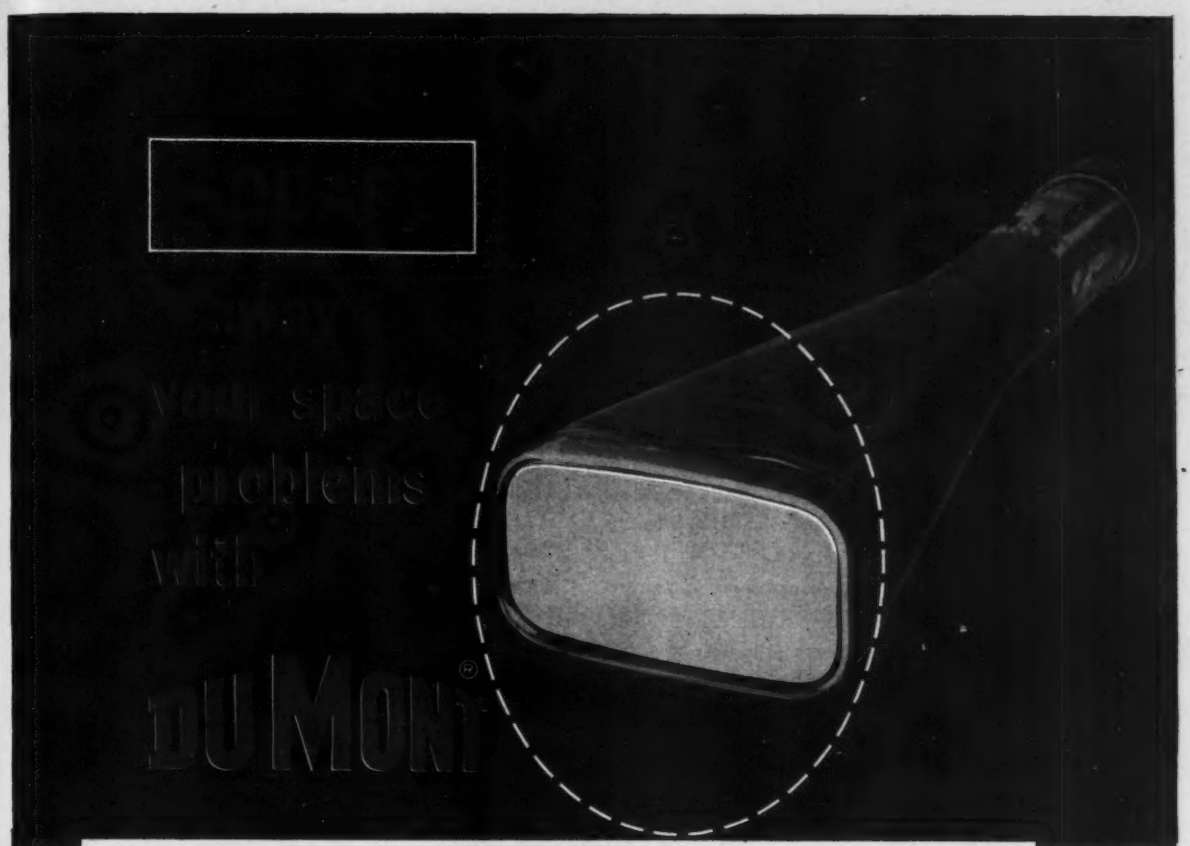
A new reflex klystron now being offered by **Sperry Gyroscope Co.,** Great Neck, N. Y., (278), features low voltage over the 8.5-10.5 kmc band. Type SRX-92 oscillator is designed for low hysteresis and high thermal stability. Applications include local oscillator in microwave receivers and spectrum analyzers, signal source in radar test sets, and low power oscillator for microwave bench work.

For more information use READER SERVICE CARD



Voltage Regulator extends tube life

THE SUPERIOR ELECTRIC CO., Bristol, Conn. Features of the Stabiline automatic voltage regulator type EM10018 include the extension of life and reliability of high-priced, complex vacuum tubes in sensitive electronic equipment. Operation is fully automatic when used with external contactors and on-off controls. When the equipment is energized, the voltage to the tubes is run-up gradually to minimize the surge strain on the filaments that appreciably shorten tube life. A control circuit auto-



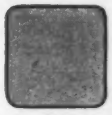
RECTANGULAR

CATHODE-RAY TUBES

Save valuable panel space by using Du Mont Rectangular Cathode-ray Tubes. These tubes permit a larger usable screen area in a given space by elimination of seldom-used segments of the circular screen.

Du Mont Rectangular Cathode-ray Tubes are available in electrostatic or electromagnetic types, in a wide range of screen sizes, shapes and materials. Write for complete technical details . . .

Rectangular screen for display of single, or superimposed patterns.



Square screen for display of two signals on a single time base.

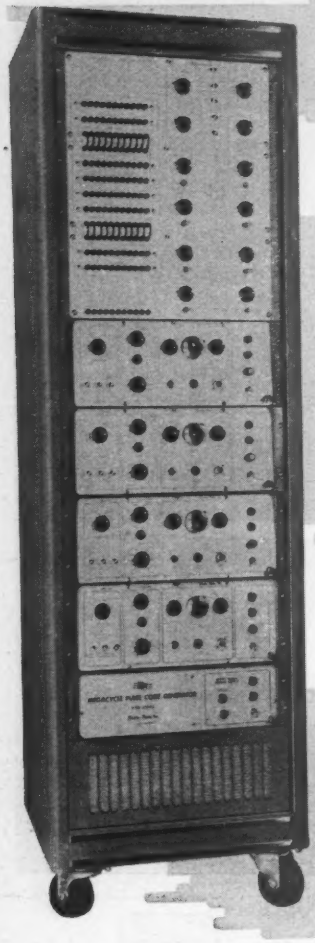
	Tube Type	Screen Size	Focus	Deflection	Max. Anode Voltage	Length
DU MONT RECTANGULAR CATHODE-RAY TUBES	B1204	4¾" x 2⅜"	Electrostatic	Electrostatic	6 KV	17⅞"
	K1206	3½" x 3½"	Electrostatic	Electrostatic	6 KV	12"
	B1167	6" x 7⅞"	Electrostatic	Electromagnetic	12 KV	10"
	B1194	3" x 1½"	Electrostatic	Electromagnetic	16 KV	10½"
	K1442	6½" x 6½"	Electrostatic	Electromagnetic	35 KV	12 3/16"

INDUSTRIAL TUBE SALES, ALLEN B. DU MONT LABORATORIES, INC., 2 MAIN AVENUE, PASSAIC, NEW JERSEY

Electro-Pulse presents

the 5100 SERIES
PULSE CODE GENERATORS
and Magnetic Core Testing Equipment

HIGH CURRENT . . . **MEGACYCLE OPERATION**



- Ten-Interval Pulse Code
- Five-Interval Controllable Repeat
- Variable Width and Delay Pulses
- Amplitude Variable to 5 Amp. per Channel—500 Mil. Avg. Current
- Independently Coded Channels
- Mixed Output— 4 Channels Pos. and Neg.

Model 5100A
Four-Channel Pulse Code Generator

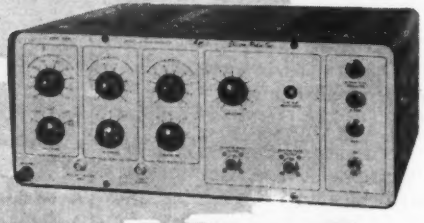
Designed for: Magnetic Memory Core Testing — Switch Core Testing — Magnetic Material Pulse Response Studies — Pulse Code Transmission System Design and Test — Multi-pulse Circuit Development.

The Electro-Pulse 5100 Series Pulse Code Generator has been developed to meet an increasing demand for higher clock rates and higher output currents necessary in data handling and related fields.

The flexible coding system is based on 10 intervals with controllable repeat of five intervals. Each channel Control Unit optionally selects (independently for each interval) a pulse or no pulse.

Four direct channels and two delayed channels feed four output amplifiers to form any required positive or negative code patterns, pulse current amplitudes, or waveforms with variable rise times.

Write for Complete Data: our Bulletin 5100A/E



Model 3450B
MEGACYCLE PULSE GENERATOR
- 2 mc to 200 cps
- Continuously variable pulse width and delay to 100 μs in 3 ranges
- Simultaneous pos. & neg. pulses

The 5100A Series and the Model 3450B are latest additions to the Electro-Pulse instrumentation line. Others: Precision Pulse Generators, Variable Pulse Generators, Time Delay Generators, Pulse Oscillators, Voltage and Current Calibrators, and Electronic Counters.

See our complete Instrumentation Display —I.R.E. Show—Booth 3611-13

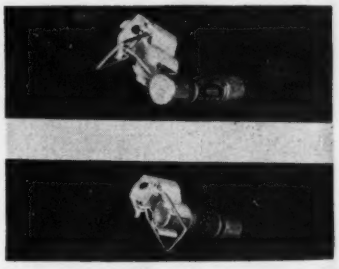
Electro-Pulse, Inc.

11861 TEALE ST., CULVER CITY, CALIF. • Phone: EXmont 8-6764 or TExas 0-8006

matically actuates at the proper time to maintain a stabilized output voltage level preset to operate the equipment at its peak efficiency.

Input is 208 v ± 10 percent, single phase, 57-63 cps. Output is 208 v nominal, 0-163 v unregulated, 163-208 v adjustable regulated, 45 amperes at 40 C ambient. Accuracy is ± 1.0 percent for rated line and load changes.

It meets various MIL specifications including shock, vibration, corrosion, moisture, fungus resistance and utilizes various MIL materials. **Circle 279 on Reader Service Card.**



Locking Clips new sizes added

ATLAS E-E CORP., 47 Prospect St., Woburn, Mass., has added new sizes to its line of locking clips. Designed to securely hold ferrule resistors and other cylindrically shaped components under extreme environmental conditions of shock, vibration and heat, they are available in silver, nickel or cadmium plating with or without solder position lug. The clips of phosphor bronze with stainless locking springs are made to BU Ships spec RE28F 121 B. The locking springs are available with a unique device for ejecting the component from the clip.

Clips for the following diameter components are now available: ¼ in., $\frac{9}{32}$ in., $\frac{13}{32}$ in., $\frac{5}{16}$ in., $\frac{11}{32}$ in., $\frac{13}{32}$ in., $\frac{7}{8}$ in., 1 in. and 1-⅛ in. **Circle 280 on Reader Service Card.**

Varicon Connectors are subminiaturized

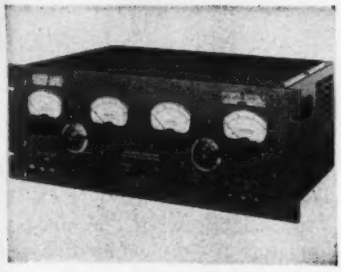
ELCO CORP., M. St. below Erie Ave., Philadelphia 24, Pa. Series

8000 subminiature Varicon connectors offer a maximum number of contacts in a minimum space. They feature screw-driver actuated locking devices, guide pins, floating mounting holes, and coaxial contact arrangements as optional accessories.

Presently available in 16, 40 and 48 contact units, contact units of 8, 24, 32, 64 and 80 will ultimately be offered—built up of 8 and 16 contact modules.

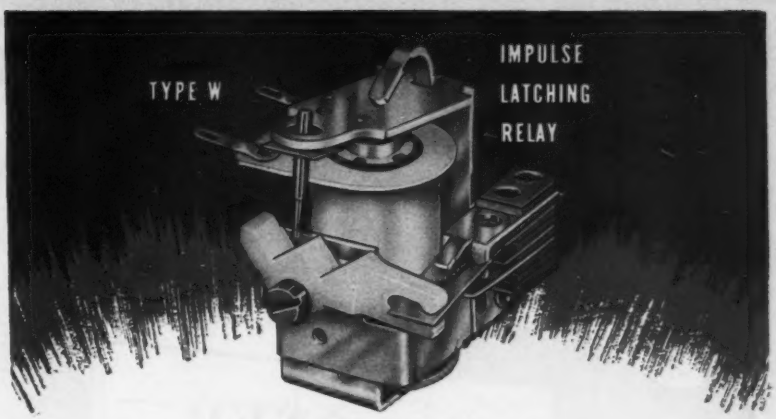
Insulator materials now available are general purpose or mica filled phenolic, Resinox 3700, and diallyl-phthallate. Other materials may be supplied on request. Excellent contact characteristics with low contact resistance are assured.

Current rating is 5 amperes; contact resistance, 0.002 ohm; and insulation resistance (dry), 25,000 megohms minimum. **Circle 281 on Reader Service Card.**



V-R Power Supply fully transistorized

KEPCO LABORATORIES, INC., 131-38 Sanford Ave., Flushing 55, N. Y., has released a new dual output completely transistorized voltage regulated power supply, model 28C-32-1.5. Each output of the dual unit delivers 0 to 32 v at 1.5 amperes continuous duty. Regulation for line or load is less than 0.03 percent or 0.003 v, whichever is greater. Ripple is less than 3 mv rms. Recovery time is less than 50 μsec. Stability for 8 hours is less than 0.03 percent or 0.003 v, whichever is greater. Resolution of 0.005 percent is obtained with a 10-turn voltage control making the output voltage continuously variable without switching. External overload and short circuit protection are included. Either positive



Features an insulated rocker arm activated by a single coil, instead of the usual two. Ideal for machine controls, appliances, positioning devices, remote TV controls and other applications where opposite switching is desired each time circuit is pulsed. Contact combinations up to 4 "C"; rated 7½ amperes @ 115 V. AC resistive.

NEW RELAYS

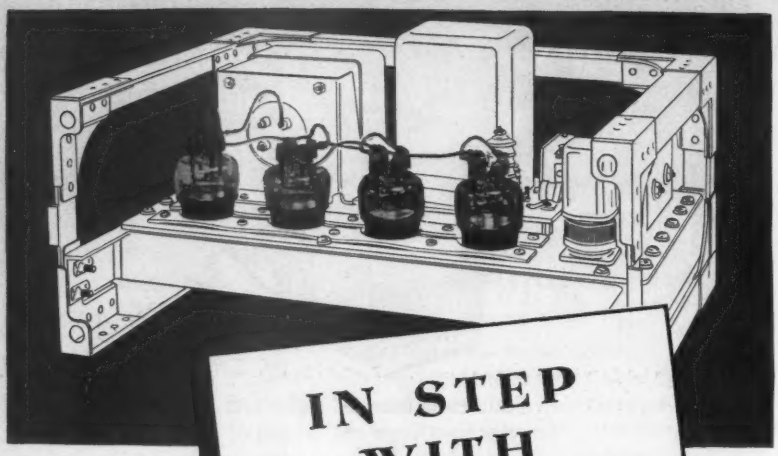
by

Comar ELECTRIC COMPANY

3349 ADDISON ST., CHICAGO 18, ILLINOIS

Suitable for use in a wide range of applications. For AC or DC operation. Compact size, lightweight. Shock and vibration resistant. Positive contact pressure. Contact combinations up to 3 "C". Contact rating, 5 amp. resistive with 5/32" dia. (10 amp. with 3/16" dia.). Available open, or in plastic dust covers with plug-in feature, as illustrated.

Send For Details



IN STEP WITH PROGRESS

JENNINGS VACUUM RELAYS

Our Country's missile development program has created demands for relays that must far exceed in performance any previous requirements. Jennings vacuum relays are being used in both the missiles and their checkout and guidance systems for their exceptional reliability under difficult operating conditions.

Four Jennings RE2 vacuum relays are used in part of a missile checkout system manufactured by Jefferson Electronic Products Corporation under contract to Sandia Corporation. In this application it is necessary that the relay reliably switch extremely small "dry circuit" voltages and currents with the entire circuit operating at a high voltage potential with respect to ground.

Jennings RE2 vacuum relay handles these requirements with ease. High vacuum processing permits all parts to be thoroughly degassed and absolutely free of any contaminants that would cause contact resistance to change from one operation to the next. The best electrical grades of borosilicate glass and alumina ceramic are used to minimize leakage by providing over one million megohms insulation resistance in the presence of high voltage. A relatively long external glass path maintains a high resistance to ground in dusty or humid atmospheres.

The R2E relay, rated at 10 kv, 10 amps rms, is also used to switch aircraft antennas and pulse forming networks. All relays are tested during vibration to insure adequate contact pressure and reliable operation.

Jennings manufactures a wide variety of vacuum relays for operation at both high and low voltage levels. Whether they be used in commercial or military equipment, they have been engineered to satisfy requirements that cannot be easily met with conventional relays.

Write for details on the RE2 and other Jennings transfer relays available now in production quantities.

Jennings RADIO

JENNINGS RADIO MANUFACTURING CORPORATION · 970 McLAUGHLIN AVE. P.O. BOX 1278 · SAN JOSE 8, CALIF.

or negative may be grounded. Units can be connected in series.

The power supply is suitable for square wave pulsed loading. Power requirements are 105 to 125 v, 50 to 400 cps. Voltmeter and ammeter are provided. The compact unit is 19 in. wide, 7 in. high and 11 in. deep. **Circle 282 on Reader Service Card.**

Power Pentode delivers extra-high output

AMPEREX ELECTRONIC CORP., 230 Duffy Ave., Hicksville, L. I., N. Y. Type 6BQ5A tube is a nine-pin, miniature power pentode designed primarily for use as a class B power amplifier in hi-fi audio equipment of over 20 w capabilities.

The 6BQ5A delivers 24 w output with only 4-percent distortion. It incorporates internal construction improvements making for higher power output with less distortion.

Detailed data and applications engineering information are available. **Circle 283 on Reader Service Card.**

Voltage Standard and null meter

KIN TEL, A Division of Cohu Electronics, Inc., 5725 Kearny Villa Road, Box 623, San Diego 12, Calif. Model 301R is a compact adjustable d-c voltage standard and null voltmeter designed for mounting in standard 19-in. racks. Direct

reading calibrated dials provide instant voltage selection with standard cell accuracy. A chopper stabilized circuit constantly compares the output with an internal standard cell to provide stability, accuracy and excellent dynamic characteristics. Power supply output voltage is 1 to 501 v. It has 4 decaded null meter ranges from 50 v to 50 mv full scale. The meter can also be used to read input voltage or the output voltage of the supply.

Model 301R, which has a wide variety of applications, features 0.01 percent stability, 0.02 percent accuracy, 0.002 percent line and load regulations, less than 100 μv ripple, 0.2 millisec response time, and less than 0.01 ohm output impedance. **Circle 284 on Reader Service Card.**

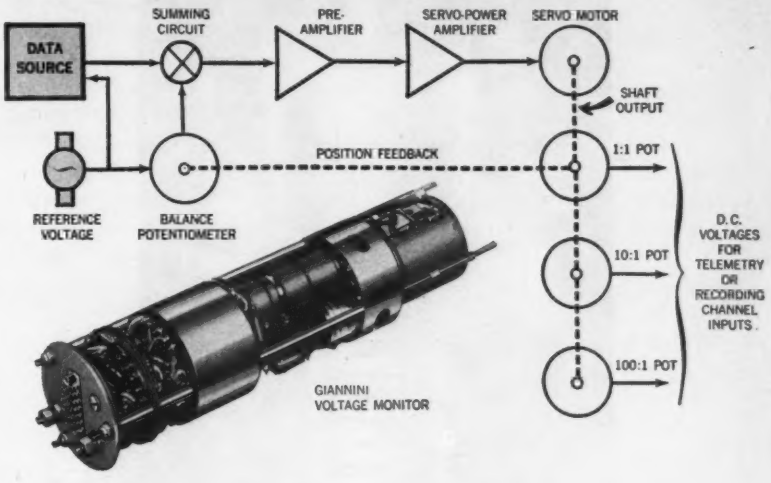
Accelerometer features simple design

CLARK ELECTRONIC LABORATORIES, Box 165, Palm Springs, Calif. A new accelerometer is 0.50 in. in diameter by 2.1 in. long and weighs 38 grams. It operates on the principle of increasing pressure, on a Celab special load cell—simplest design for sensing acceleration. A manual adjustment provides a resistance change between 10 and 1,000 ohms per G and a lock nut for holding this adjustment. As the unit has no moving parts or aging characteristics it is considered of the utmost reliability.

A rating of 1 w provides sufficient power to indicate directly on a meter system without the use of amplifiers. While the unit shown

For 0.035% Accuracy in your Airborne Data...

...Giannini DATA REPEATERS



GIANNINI PRECISION VOLTAGE MONITORS are Data Repeaters which utilize the scale multiplying technique. They have an inherent accuracy of 0.035% under all conditions, and repeatability of one part in ten thousand. This is the first time that such accuracy has been possible in a small (2¼" x 9") unit capable of withstanding the extreme environments of airborne operation.

THE PRECISION VOLTAGE MONITOR alters a transducer or control system signal so that data relayed to the telemetering or recording system is less susceptible to system errors. A unit designed for incorporation in the airborne telemetering system of Chance Vought's Regulus II results in telemetered data with approximately 0.04% overall error. This figure is conservative, and includes the effects of all unit error sources such as hysteresis, linearity, temperature effects, and long term drift, as well as telemetering system error.

A VOLTAGE MONITOR CONVERTS AC output signals from an airborne data source into 3 DC voltages, representing the data to four or more significant figures. These three separate units of information are fed into the telemetering or recording system on three separate channels. The result is transmitted information with an accuracy of four or five significant figures.

WITHOUT CHANGING THE CIRCUITRY of the transmitting system in any way, errors incurred in transmittal are restricted to the fourth or higher order significant figures.

Designed to satisfy the extreme environmental demands of aircraft and missile data systems, Giannini Precision Voltage Monitors are also readily adaptable to other airborne or industrial applications requiring precise voltage monitoring, data repeating, or data multiplexing. They are available in voltage ranges from 0.0 to 0.8v to 0.0 to 100.0v, and sizes from 2¼" x 6" to 2¼" x 9".

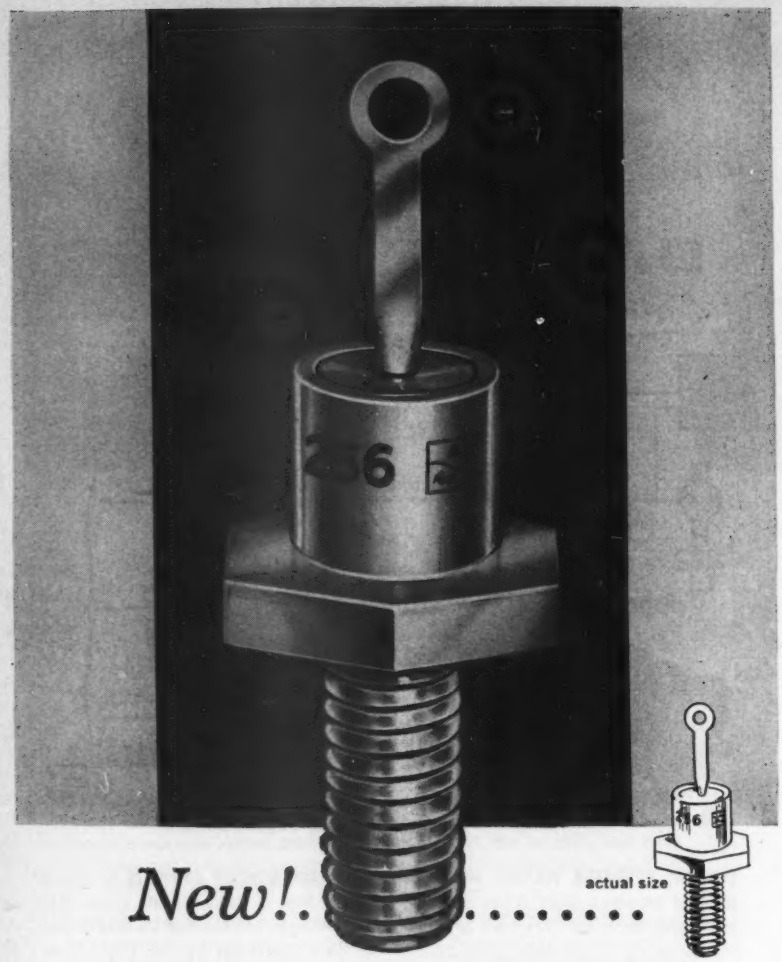
Giannini measures & controls:

ϖ	β	θ	ψ	τ	v	ϕ
δ	Ω_s	α_t	h	P	ΔP	T
T_s	P_s	Qc	M	T_o	P_T	TAS

PRECISION INSTRUMENTS SYSTEMS & CONTROLS

Giannini

G. M. GIANNINI & CO., INC., 918 EAST GREEN STREET, PASADENA, CALIF.

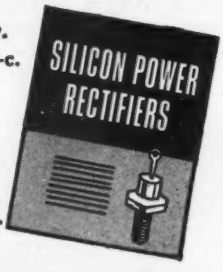


New!.....

SILICON POWER RECTIFIERS

53 TYPES including military 1N253, 1N254, 1N255 and 1N256

- **200 ma to 1 amp current capability.**
- **Voltage ratings from 50 to 1000 vd-c.**
- **Reliable operation at 150°C.**



Send for bulletin 58R . . .

MICROWAVE ASSOCIATES INC.

Burlington, Massachusetts • BRowning 2-3000

weighs 38 grams, it can be further miniaturized by about 5 times if required. Its temperature limit is 500 F, but this is expected to be extended considerably in time. **Circle 285 on Reader Service Card.**

Telemetering Supply regulated dual output

POWER SOURCES, INC., Burlington, Mass., has available model PS-1010 regulated dual output telemetering supply. The completely transistorized unit occupies less than 58 cu in. and provides 2 outputs each regulated to within ±2 percent, 180 v at 0-70 ma and 108 v at 0-85 ma. Ripple on both outputs is below 100 mw.

Regulation will hold over an input of 28 v d-c ±8 percent and any combination of loads from 0 to full load. The unit is capable of continuous operation under conditions of 100 g shock, 150 zero to 2,000 cps vibration, and sustained accelerations of 100 g. It has an operating temperature range of −55 C to +85 C. The unit is designed to operate with a heat sink mounting temperature of 185 C during its final 30 seconds of flight. **Circle 286 on Reader Service Card.**

Power Pulser no moving parts

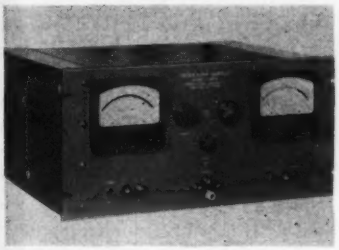
TORWICO ELECTRONICS, INC., 1090 Morris Ave., Union, N. J. A l-f power interrupter incorporating a specially designed magnetic amplifier involving no thermal or mechanical devices has been added to the Tynymag line.

The magnetic power pulser is extremely rugged since no heaters or moving parts are involved. It will

operate with high reliability and long life with minimum maintenance. The pulser operates on a 60 cps or 400 cps line and is entirely self exciting. It can be provided to pulse a 60-cps line at rates from 1 cycle per minute to 3 cps. On 400 cps it can pulse from 1 cpm to 60 cps. External adjustment can be provided over approximately an 8 to 1 range.

Power output can be provided up to 100 w d-c. Higher power up to 10 kw a-c can be pulsed with the addition of a supplementary saturable reactor. Size is dependent on power rating.

Pulsing is free from steep wavefronts and develops no h-v transients, arcing, or radio interference signals. No biasing, starting mechanisms, or warmup time are required. Ambient temperature range is — 55 C to + 100 C. **Circle 287 on Reader Service Card.**



Regulated Supply for transistor circuitry

DRESSEN-BARNES CORP., 250 North Vinedo Ave., Pasadena, Calif., has announced a closely regulated d-c power supply designed for use in transistor research and development, in transistor testing, and original equipment. The unit meets recently-arisen industry demands for heavier-current output, low ripple and low draft in a power supply.

Output is 0 to 60 v d-c, continuously variable, at 300 ma maximum. No derating of output current, or of regulation and ripple specifications, is necessary from 1 to 60 v d-c.

Regulation for 60 v/300 ma load is 20 mv change, no load to full load. For line voltage change of 105 to 125 v a-c (at 60 v/300 ma output), regulation is 20 mv change

4 Ounce Contact Force Gives Relay Reliability

Contact force of 4 ounces per contact on 50 "G" models and 2 ounces per contact on 30 "G" models of "Diamond H" Series R and Series S miniature, hermetically sealed, aircraft type relays is one of the most important factors in their proven high reliability.

Though absolute reliability of any similar device is impossible to guarantee—a bitter fact of life recognized by all electronic engineers—close approach to this goal by the relays manufactured by The Hart Manufacturing Company is the basic reason they are found today on many of this country's headline-making missiles.

In addition to contact force far beyond that found on other relays, "Diamond H" relays have greater contact cleanliness. Self-contamination is virtually eliminated by a completely inorganic switch mechanism, as well as use of coil materials which will not dust, flake or out-gas.

Finally, the high degree of reliability that is designed into these relays is maintained in their manufacture by high quality workmanship and a stringent inspection policy at every stage.

In addition to missiles, and their ground control systems, Series R and S relays are designed for use in jet engine controls, computers, fire control, radar and similar critical applications.

4PDT units, they offer an extremely broad range of performance characteristics, including temperature ranges from —65° C. to 125° and 200° C.; ratings to 10 A., 120 V., A. C., and 26½ V., D. C., with special ratings to 400 ma. at 350 V., D. C., or down to millivolts and milliamperes. Dry and wet circuits may be safely intermixed.

For more information, write today for Bulletins R250 and S260. For quick facts about "Diamond H" switches, thermostats and other devices, ask also for a copy of the "Diamond H" Check List of Reliable Controls.

THE HART MANUFACTURING COMPANY

202 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

Magnet Charger

HEADQUARTERS

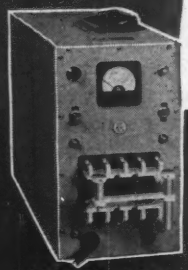
MODEL 942

Recommended by Leading Magnet Makers

3 VERSATILE MODELS

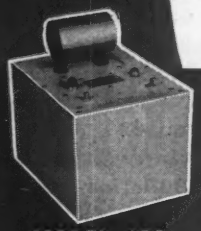
For saturating Alnico magnets weighing up to 34 lbs. and high flux ceramic magnets of any shape or pole configuration. Operates on condenser discharge principle from regular 115-volt, 60-cycle line.

Charging outputs from 100,000 to 200,000 ampere-turns through plug-in transformers, up to 3600 watt-seconds using wire-wound fixtures. Adapters for multi-pole rotors, rod, bar, ring and various other shapes available. Designed for continuous production use with low power consumption. Price of basic unit is less than $2100.



MODEL 107A

A basic condenser discharge unit for most medium size magnets, the Model 107A provides ranges of 12,000 and 24,000 ampere-turns. It is capable of saturating most instrument magnets, including the new core type mechanisms, using adapters or wire-wound fixtures. Designed for continuous duty. Operates from 115-volt, 60-cycle line. Price $530.



MODEL 1221

A low cost, condenser discharge unit employing novel, plug-in wire-wound type charging fixtures, the Model 1221 is designed for the user of small magnets. Its 10,000 ampere-turn output will saturate about 2" of Alnico V. Charging cycle rate is approximately 3 seconds, continuous duty, operates from 115-volt line. Price $180.

Performance of all models is rigidly guaranteed. Prices are net f.o.b. Boonton, N.J. and subject to change without notice.

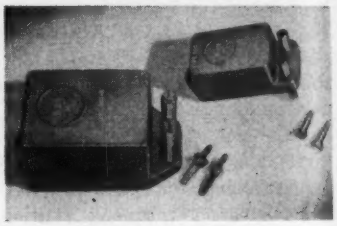
WE CAN HELP YOU

12 years' magnet charging experience is yours for the asking—send for illustrated data sheets.

RFL *Radio Frequency* LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

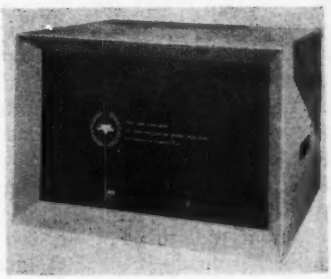
in output voltage. Ripple and internal noise are below 1.5 mv rms. The unit is designed for very low output impedance and fast recovery time. One-percent meters are provided.

Designated as model .6-300B, the instrument is built to fit in a standard 19 in. relay rack. **Circle 288 on Reader Service Card.**



Mica Capacitors low price units

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. Type 505 mica capacitors are adjusted to ±0.5 percent and are packaged in a less-expensive case than the company's standard capacitors. They are available in a 1-2-5 series extending from 100 $\mu\mu$f to 0.5 μf. Dissipation factor for the 1,000-$\mu\mu$f and higher sizes does not exceed 0.0003. Capacitors are housed in low-loss molded-phenolic cases and are equipped with both screw- and lug-type terminals and mounting flanges. **Circle 289 on Reader Service Card.**

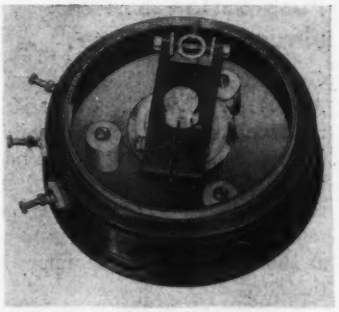


Voltage Regulator magnetic amplifier type

Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif. Model MIR-3000 is a magnetic amplifier regulated 3 kva tubeless a-c line voltage regulator. It con-

tains no moving parts or vibrating contacts, and regulates the rms value. Input voltage range over which the unit operates within specifications is 95-135 v, and the output voltage is 115 v nominal adjustable from 110-120 v.

Regulation accuracy is ± 0.50 percent for any combination of line and load changes and the frequency range is 60 cps ± 10 percent. Wave form distortion is 3 percent maximum, and power factor range is 0.7 lagging to 0.9 leading. Maximum load is 3.0 kva and response time is 0.1 to 0.2 sec. The unit, representing the ultimate in reliability, is ideally suited for laboratory and production testing, and is especially designed for remote unattended installations. **Circle 290 on Reader Service Card.**



Potentiometer dynamic balance design

Chicago Aerial Industries, Inc., 1980 Hawthorne Ave., Melrose Park, Ill. The 1000 series pots incorporate dynamic balance which enables mechanical performance to match electronic precision. Standard linearity is 0.1 percent, 0.2 percent for miniatures.

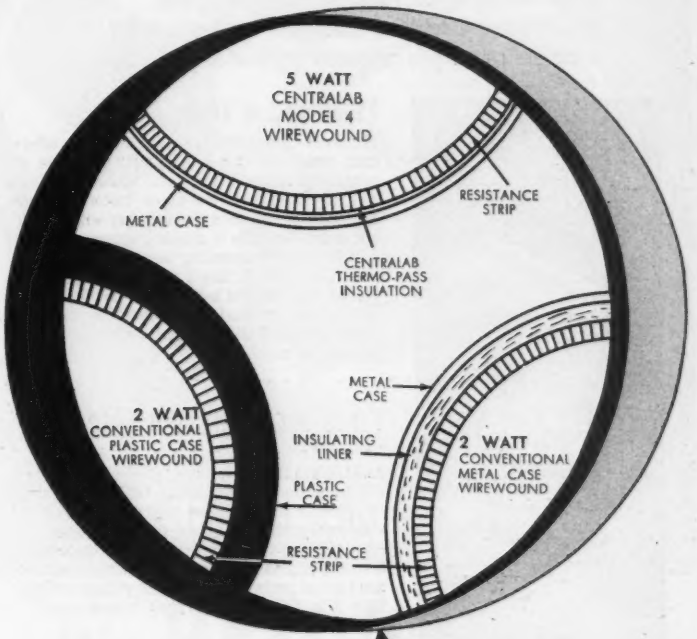
The concept of dynamic balance centers around the contact. The arm is rigidly clamped and dynamically balanced with respect to the shaft. The small, light and rigid contact assembly is mounted in jeweled pivot and is dynamically balanced with respect to the arm. Because of dynamic balance only very light spring pressure is needed to assure constant contact with the winding even under the most severe environmental conditions.

Performance-wise the 1000 series

5 watt capacity – 2 watt size

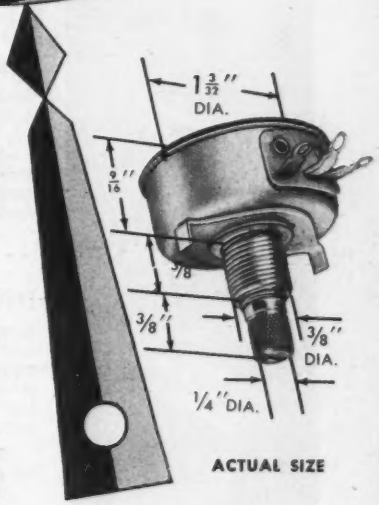
Centralab MODEL 4

Miniature Wirewound Radiohms®



As you know, the rating and size of a variable resistor depends upon the speed with which heat can be transferred from the resistance element to the atmosphere. Centralab "thermo-pass" insulation combines exceptional heat transfer with a dielectric strength of 4500 volts per mil at 25° C. Result: Model 4 Radiohm, a conservatively rated 5 watt wirewound variable resistor smaller than a conventional 2 watt unit.

- **Only 1 3/32" diameter by 9/16" deep.**
- **Resistance range, 1 ohm to 15K ohms; linear taper.**
- **295° rotation, stop strength 15 inch pounds.**
- **Minimum life, 25,000 complete cycles.**
- **Totally enclosed elements.**



ACTUAL SIZE

For detailed information write for Centralab Engineering Bulletin EP-493 or contact your Centralab sales representative. Ask your local distributor about the many values he carries in stock in the WW and WN series (listed in Catalog 30).

Centralab
B-5810

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In Canada: 804 Mt. Pleasant Rd. • Toronto, Ontario

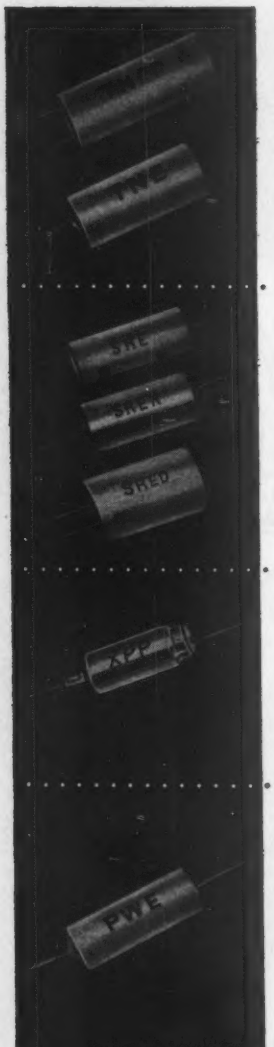
VARIABLE RESISTORS • PACKAGED ELECTRONIC CIRCUITS • ELECTRONIC SWITCHES
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

The LARGEST Selection of the SMALLEST

ELECTROLYTICS

is available from AEROVOX!

...and only from Aerovox can you choose from the widest selection of case styles and constructions in a complete range of low-voltage values. For small space applications... for transistorized assemblies...ALL your requirements for miniature electrolytic capacitors are available from Aerovox.



TYPES TNE & TNED

Preferred type subminiature electrolytics where cost, small size and long operating life are of prime importance in transistor assemblies. These tiny, low-impedance, low power factor units are furnished in film-lined glossy tubes with plastic end seals. Available in standard voltage ratings of 3 to 50 vdc with operating temperature range of —30°C to +65°C. Leads are firmly imbedded in plastic end seal and will not pull out or work loose under the most severe operating conditions: Color coded end-fill and case marking denotes positive terminal.

TYPES SRE, SREN, AND SRED

Improved electrolytics especially suitable for cathode bypass applications, screen circuit filters and transistorized assemblies. Units tightly sealed in tubular aluminum cases available with external wax-impregnated cardboard insulating tube. Exclusive end-seal provides greater creepage distance and assures positive electrical and mechanical contact. Standard dc voltage ratings from 3 to 150 volts. Operating temperatures from 0°C to 85°C.

TYPE XPP

Miniature, hermetically-sealed, **metal-cased** tubular aluminum units designed specifically for maximum life where size and weight must be kept to a minimum. Exceptional shelf-life characteristics. Standard voltage ratings of 1 to 5 vdc and standard temperature range from —20°C to +65°C. Available with axial leads only.

TYPE PWE

Miniature electrolytics encased in dense steatite tubes with special plastic end fill. Offering high capacitance at low voltages, these units are capable of handling full-size loads in industrial applications. Standard voltages from 1 to 50 vdc and standard operating temperatures from —20°C to +50°C.

For detailed technical information write...

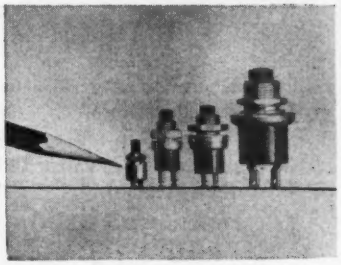
AEROVOX CORPORATION

NEW BEDFORD, MASS.

AEROVOX Capacitors

meet and surpass NAS-710. A 5,000,000 cycle life, 2,000 cycle vibration at 30 g's, and speeds from 1,000 to 3,425 rpm (depending on size) are standard.

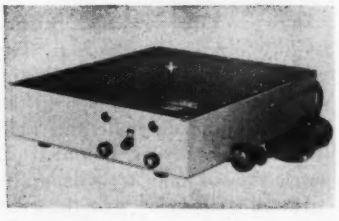
The pots are produced in six sizes from $\frac{3}{8}$in. to 3 in. Mechanical rotation is 360 deg continuous, but phaseable stops are available. Operation up to 225 C is available and 165 C is standard. **Circle 291 on Reader Service Card.**



Push-Button Switch ultraminiature type

GRAYHILL, INC., 561 Hillgrove Ave., La Grange, Ill., Series 39-1 ultraminiature push button switch is a spst, momentary contact, normally open model, conservatively rated 1/10 ampere at 115 v a-c resistive. Life expectancy is rated at 200,000 operations minimum at the rated load.

The switch is 0.250 in. diameter, has an overall length of 0.615 in., with 0.315 in. behind the panel, including the soldering terminals. It is designed for use with $\frac{1}{16}$ in. panels and requires a $\frac{3}{16}$ in. hole for mounting. The red push button has approximately $\frac{1}{32}$ in. movement. **Circle 292 on Reader Service Card.**



Degausser for tape erasure

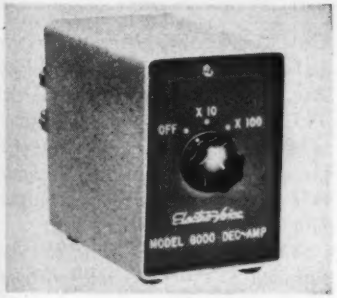
CINEMA ENGINEERING, DIVISION AEROVOX CORP., 1100 Chestnut

St., Burbank, Calif., is marketing its No. 9205-A commercial tank-type degausser for erasing program material and residual noise from magnetic tape and film. In two powerful magnetic fields it degausses up to 5,400 ft of ¼ in. tape and 1,000 ft of 35 mm film.

The degausser was designed especially for industrial use with heavy duty double fuse and double pole switch. The copper and iron used in the demagnetizing coils are engineered for heavy industrial usage. Unit is equipped with rubber feet for bench use and operates from standard 115 v, 60 cycle power source.

Model 9205-A has black phenolic top with locating spindle; degaussing being accomplished by rotating reels by hand on top of surface of unit.

Besides the degausser the factory also produces a magnetic erasing pencil, type 8905, for use when a relative limited area of magnetic tape or film must be erased. **Circle 293 on Reader Service Card.**



Transistor Amplifier wide band, low noise

ELECTRO-VOICE INC., Buchanan, Mich., announces the model 6000 Dec-Amp. Four selected transistors in a highly stable circuit, together with precision components, result in an instrument exhibiting exceptionally low inherent noise. Amplification accuracy is unaffected by normal battery voltage reduction or changes in ambient temperature. The Dec-Amp is powered by a self-contained mercury battery which permits a small, neat portable design. It has numerous applications in laboratory, field or production.

Available gain is either X10 or

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for timing devices

If you're looking for a complete product line *that includes Timing Devices for every application requirement and, in addition, features the highest quality and most advanced design at the lowest possible cost, HAYDON has it! And all Haydon timing devices incorporate the famous Haydon hysteresis and/or inductor timing motors available for 50, 60, and 400 cycle and DC power supplies.*

If you're looking for a complete service *to meet all your timing needs, HAYDON offers fully integrated engineering and manufacturing facilities ready to take your timing projects right through from design and development to finished product!*

And if you're looking for a complete Field Engineering Service *to make all these facilities conveniently available, you'll find there's a HAYDON Timing Specialist in your area, a man fully qualified by training and experience to help fill your Timing Device needs. Why not phone him today and make an appointment to discuss your requirements?*

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A SUBSIDIARY OF GENERAL TIME CORPORATION

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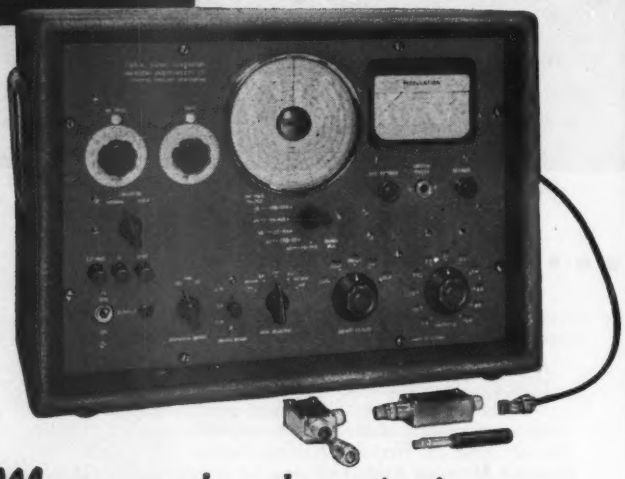
MARCONI

FM/AM SIGNAL GENERATOR

Model 995A/2 for both r.f. and i.f. testing with c.w., f.m., a.m., or simultaneous f.m. and a.m.

The MARCONI Signal Generator Model 995A/2 is an accurate and dependable instrument of broadest applicability. It covers from 1.5 to 220 Mc in five bands and there are facilities for crystal standardization from 13.5 Mc upwards. A precision slow-motion mechanism is employed for the main tuning drive *and*, for making bandwidth measurements, there is a separate directly-calibrated incremental control. The open-circuit output level is variable, in 1-dB steps, from a minimum of 0.1 microvolt to a maximum of 100 millivolts at 52 ohms and 200 millivolts at 75 ohms. The output may be continuous wave, frequency modulated, amplitude modulated, or simultaneously both frequency and amplitude modulated. The modulation, obtained either from an internal 1000-cps oscillator or from an external source, is variable to maximum frequency deviations ranging from 25 to 600 kc for f.m., and to depths up to 50% for a.m. Send for leaflet B/115B for full details.



Marconi for f.m. test gear

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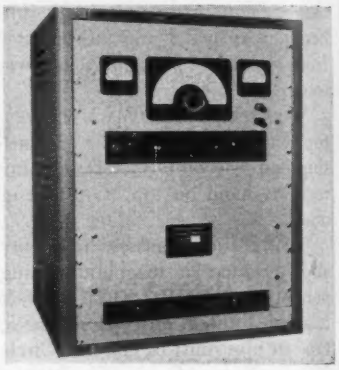
TC115

X100 from 10 cps to 1 mc ±0.2 db. Input impedance is 50,000 ohms shunted by 8 $\mu\mu$f, and output impedance is 150 ohms. Maximum noise referred to the input for a 1 mc bandwidth is 50 μv. Maximum output at less than 0.5 percent total harmonic distortion is 1.0 v, rms; battery life, 300-500 hours. Overall size is 3¾ high by 2½ wide by 5½ deep. **Circle 294 on Reader Service Card.**



Power Generator ultrasonic type

COMMUNICATION MEASUREMENTS LABORATORY, INC., 350 Leland Ave., Plainfield, N. J. Model 1432-U ultrasonic power generator is of 500 va capacity. It is one of a group of generators in the ultrasonic field which cover a power output range of from 25 va to 2 kva.

All units in this line can be supplied to cover discrete portions of the 5 to 50 kc range with a frequency spread ratio of 3.6 to 1. Common ranges are 10 to 36 kc or 15 to 50 kc. Output voltage regulation is normally within 10 percent from full load to no load, however 3 percent regulation can be supplied on order. Harmonic content of the waveform is low.

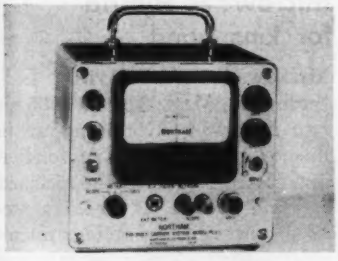
Various output impedance ranges are available. **Circle 295 on Reader Service Card.**

Carrier Equipment five extra channels

BUDELMAN RADIO CORP., 375 Fairfield Ave., Stamford, Conn., is producing their latest improved

telephone carrier current equipment, type 16B. Designed specifically to provide a low-cost rural telephone carrier expansion of five additional channels (50 new subscribers to an existing wire pair), the type 16B utilizes thoroughly tested double sideband a-m circuits. A complete channel (10 new subscribers) can be installed in as little as four hours on a "connect" and "operate" basis.

A complete channel of carrier consisting of both terminals (central office and subscriber) together with essential accessories, in many cases costs less than poles, wires, labor and supplies for open wire line construction. Without accessories, a complete type 16B channel with selective ringing costs only $735. **Circle 296 on Reader Service Card.**



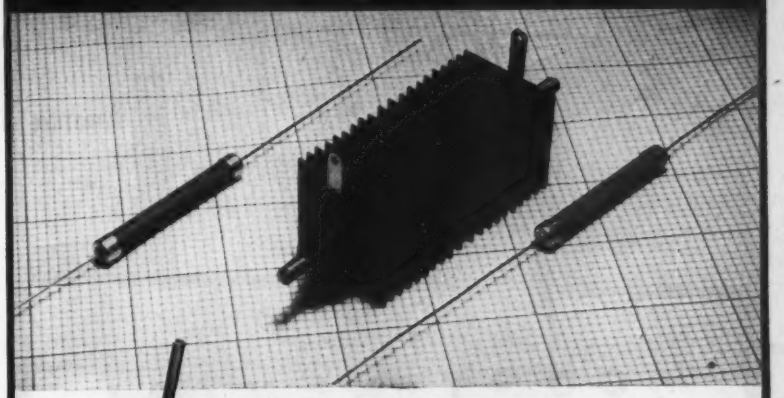
Carrier System features portability

NORTHAM ELECTRONICS, INC., 2420 North Lake Ave., Altadena, Calif., has developed a new single-channel portable 3 kc carrier system, model PCS-1, designed for use with variable reluctance transducers. Weighing only 10 lb the PCS-1 includes a 3 kc oscillator to excite the transducer coils, a full wave transistor switch demodulator and a panel meter to indicate transducer output.

An auxiliary is the model F-1 filter, which may be plugged into the basic carrier unit to provide a suitably filtered output for driving such readout instruments as oscilloscopes, oscillograph, strip-chart and pen recorders. There is an additional output jack available to permit operation of a remote meter as another alternative readout.

Specifications of the PCS-1 call for a regulated excitation voltage from the oscillator of 10 v rms at

Leading rectifier manufacturers select TUFF-TUBE to meet specifications...



...* and cut costs, too!

In high voltage rectifiers for military and commercial applications, the material used for housings and insulating tubes is of critical importance. Latest military specifications are calling for prolonged voltage surges, higher temperatures, severe humidity plus other rigid requirements. Add to these the necessity for high strength, light weight and close mechanical tolerances—the result is a difficult problem in material selection.

Leading rectifier manufacturers are solving this problem with **Lamtex TUFF-TUBE,** a high quality fiberglass-epoxy laminated tubing. Lamtex's exclusive impregnation and curing process, together with strict quality control, seals in properties that are unmatched for electronic component applications.

* A typical material formerly used for this application was glass-melamine G5. Direct cost comparison proved Lamtex TUFF-TUBE more economical, up to 16% savings in some cases.

Electronic design engineers are using TUFF-TUBE for waveguides, coil forms, spacers, component jackets, antenna housings, brush holders, tuning coils, motor insulation, commutator and printed circuit forms, and many other applications that require any or all of these characteristics:

INSULATION RESISTANCE
DIELECTRIC STRENGTH
HUMIDITY-PROOF
HIGH TEMPERATURES
LIGHT WEIGHT
HIGH STRENGTH
THIN WALLS, FROM .008"
SMALL DIAMETERS, FROM .062"
DIMENSIONAL STABILITY

AVAILABLE IN ALMOST ANY CROSS-SECTION SHAPE

Write for complete info — design features, tech data, application notes.

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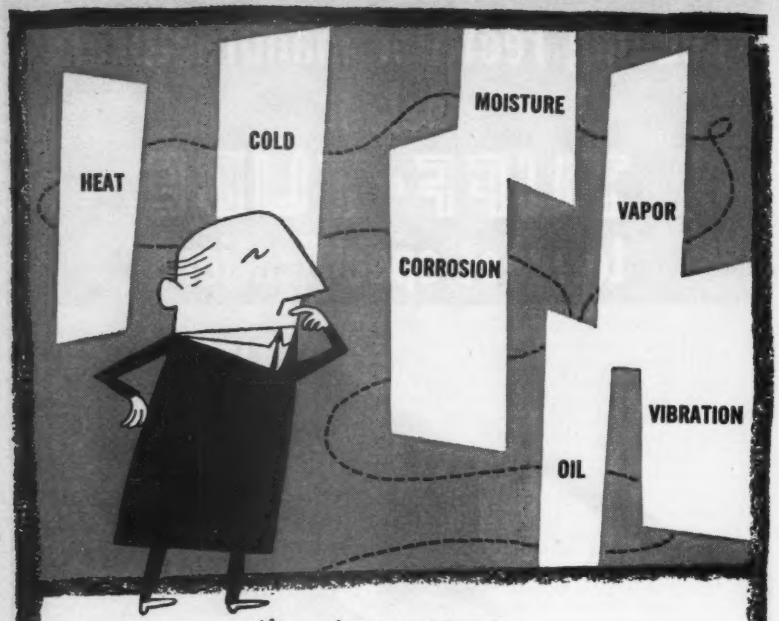

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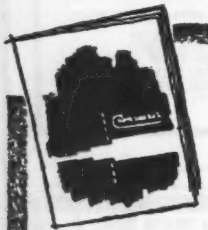
insulated electronic wire

No door is closed to the company that specifies Continental insulated wire or cable. That extra tough problem requiring seemingly impossible performance of wire may have you asking "What wire?" Why not let Continental's engineering help? There's a wide range of wires developed for special applications at Continental everyday.

Maybe the answer that you've been after is even now a standard in the Continental line. It's worth a letter or call today.

ELECTRONIC INSTRUMENT INSULATED WIRE

600-3000 volt service. Sizes: 32 AWG to 6 AWG inclusive.
CONSTRUCTION: stranded tinned copper, polyvinyl insulation with or without nylon jacket. Maximum operating temperature: 100°C.
CONFORMS TO: MIL-W-16878B
COLOR CODED: 1, 2, or 3 spiral stripes over polyvinyl insulation.



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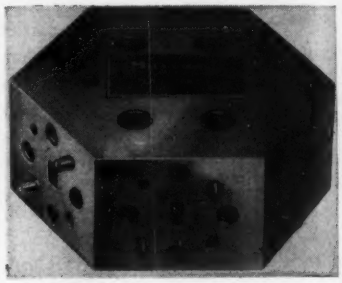
3 kc and a demodulator output current linearity of better than 1 percent full scale, providing 1.0 ma into 50 ohms. When the F-1 filter is used, an output signal flat within ± 3 percent from 0 to 250 cps is available to drive either an oscilloscope or a recording oscillograph galvanometer. **Circle 297 on Reader Service Card.**



Microwave Hybrid for kmc band

MICROWAVE ASSOCIATES, INC., Burlington, Mass. The MA-606 rat race microwave hybrid for use in the 68-73 kmc band has an isolation in excess of 20 db over the specified bandwidth. The rat race is a precision power divider useful in microwave systems wherever exact power division with negligible cross talk is required. When used in conjunction with two mixer crystals, such as the MA-412, the assembly will perform as a balanced mixer.

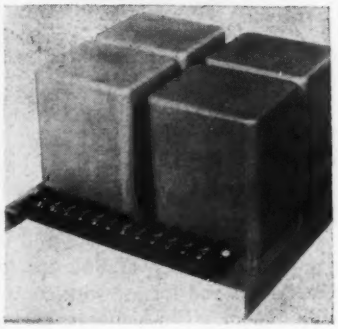
MA-606 has a vswr of 1.25 maximum; isolation, 20 db minimum; balance, ½ db. Mating surfaces of the MA-606 connect with flange type UG-385/U used with RG-98/U waveguide. **Circle 298 on Reader Service Card.**

Dual Power Supply for transistor use

DRESSEN-BARNES CORP., 250 North Vinedo Ave., Pasadena, Calif.

lated d-c power supply for use in transistor circuits. It is equipped with two outputs, each 0 to 60 v d-c continuously variable at 300 ma maximum. Both outputs are electrically separated, and both float above ground—hence either output can be used as a positive or a negative supply, or the two can be connected in series.

No derating of output current or of regulation and ripple specifications is necessary from 1 to 60 v d-c. Regulation for 60 v/300 ma load is 20 mv change, no load to full load. For line voltage changes of 105 to 125 v a-c (at 60 v/300 ma outputs), regulation is 20 mv change in output voltage. Ripple and internal noise are below 1.5 mv rms. Unit is designed for very low output impedance and fast recovery time. One percent meters are provided. **Circle 299 on Reader Service Card.**



Antirepeat Control with no moving parts

CLARK CONTROLLER CO., Cleveland, Ohio, has announced an antirepeat press control with no moving parts, for use with its type PV protector air valve. Instead of relays, the device utilizes magnetic amplifiers, diodes, a transistor and a pulse transformer. Therefore, it has no moving parts for inspection and maintenance, and is not subject to wear, corrosion, and dust interference.

The new unit provides all the safety performance of the company's antirepeat control using relays. It has external connections essentially like those of conventional controls, and operates on 115-v a-c power. It receives input

Twelve-and-a-half microvolt resolution at 20 readings per second! That's the outstanding feature of the analogue-to-digital converter, developed by Non-Linear Systems, Inc., Del Mar, California, to "digitalize" the output of low voltage transducers in either ground or airborne service.

It's significant that Non-Linear Systems engineers selected fourteen miniature Bristol Syncroverter* high speed relays (inset, top) for use in the converter scanning circuits. For the Syncroverter was originally designed for use in our own Bristol instruments in extremely critical, low-level, dry-circuit applications. Its rugged non-resonant construction has earned it an enviable reputation for reliability, long life, and immunity to shock and vibration.

Write for complete data. Characteristics below are typical. The Bristol Company, 152 Bristol Road, Waterbury 20, Connecticut. 8.3

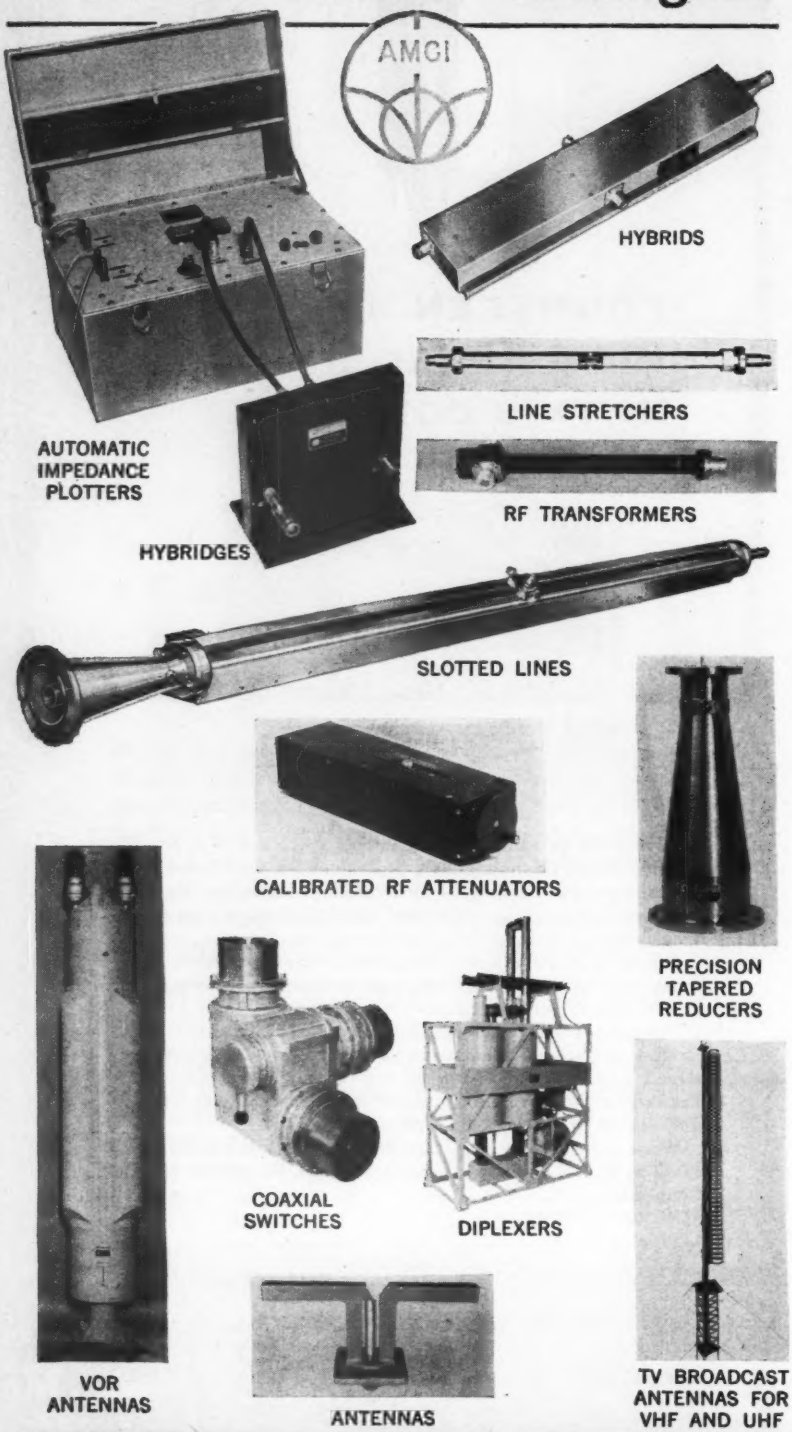
*T. M. Reg. U. S. Pat. Off.

TYPICAL CHARACTERISTICS
Bristol's Syncroverter High-Speed Relay SPDT or DPDT (covered by patents)

Temperature range:	−55°C to 100°C
Operating shock:	30G; 11 milliseconds duration
Vibration:	10-55 cps (see below, mounting); 10G
Contact ratings:	Up to 35V, 45 microamperes
Stray contact capacitance:	Less than 15 mmf.
Pull-in time (including bounce):	As low as 200 microseconds
Drop-out time:	300 microseconds
Life:	Over a billion operations under dry-circuit conditions
Mounting:	Octal tube socket; others available, including types for vibration to 2000 cps

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER 68 YEARS

From the AMCI Catalogues



AMCI

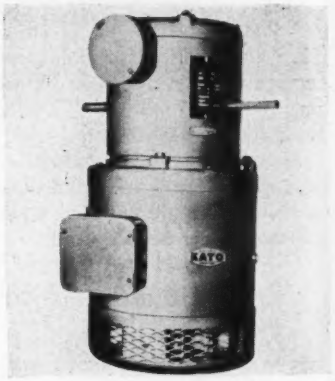
ANTENNA SYSTEMS—COMPONENTS—AIR NAVIGATION AIDS—INSTRUMENTS

ALFORD Manufacturing Co Inc

299 ATLANTIC AVE. BOSTON, MASS

signals from the press "run", "stop", and "inch" buttons and the press limit switches, and delivers its output to the magnet of the type PV air valve.

Essentially a safety device interposed between the operators' control buttons and the press, the Transmag antirepeat control prevents operation of the press unless safe conditions exist. **Circle 300 on Reader Service Card.**



Motor-Generator Set vertical type

KATO ENGINEERING CO., 1415 First Ave., Mankato, Minn. This vertical type motor-generator set has an input frequency of 60 cps and an output frequency of 360 cps. It was developed for use with control equipment. The higher frequency, when placed on normal 60 cycle lines, will interrupt frequency selective circuits, enabling power equipment to be turned on or off remotely

This machine operates at 1,800 rpm. The motor and generator are on a common shaft. The single phase output of this 360 cycle unit is 500 w. **Circle 301 on Reader Service Card.**

Sound Spectrograph provides record analyses

KAY ELECTRIC CO., Maple Ave., Pine Brook, N. J. . The Sona-Graph model recorder is a new sound spectrograph that makes a permanent, storable aural record in addition to three visual analyses of any audio vibrations in the

85-12,000 cps range. The display graphs are made in two switched bands, the first from 85 cps to 6 kc, and the second from 6 kc to 12 kc. An added feature is that with only slight loss in output and amplitude the Sona-Graph can be adapted to study such subsonic vibrations as heart and brain waves.

The recording medium is a flexible magnetic disk 12 in. in diameter and approximately 3 mils thick. It can be removed and filed with the visual analyses, or it can be reused as often as desired. The three permanent graphs are 4 in. by 12 in. on 5⅞ in. by 12¾ in. facsimile paper. **Circle 302 on Reader Service Card.**

VHF System weighs 22 lb

AIRCRAFT RADIO CORP., Boonton, N. J. Model 210 vhf communications system weighs only 22 lb. It provides a frequency coverage of 118 to 135.95 mc on 360 channels and is suitable for both military and commercial aircraft. Included in the total weight are the transceiver (illustrated), mountings, control panel and power supply. The unit has true 50-kc channel spacing, a 15-w transmitter with a very low, spurious output and a receiver sensitivity of 2 μv.

By turning a switch on the control panel, the system can be operated either as a single-channel simplex or double-channel simplex with 6-mc operation.

The system is powered by a dynamotor designed to give maximum dependability with the least possible weight. An advanced type of center-of-gravity mount reduces vi-

New PRECISION FREQUENCY

STATIC INVERTER SUPPLY

INPUT 28V D.C. ± 10%

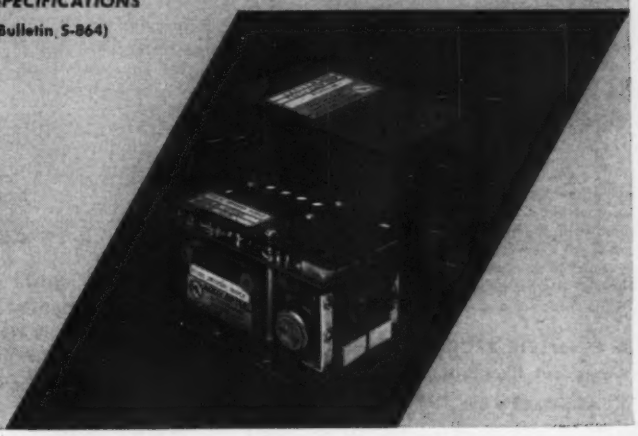
OUTPUT Nom. 115V ± 2% 400 CPS ± 0.01%
1 ϕ (2- or 3-phase output available)

RATINGS: 30VA 50VA 100VA
Higher ratings available.

APPLICATION:
For gyro wheel supplies and where precise 400 cycle voltages are required in aircraft, radar and missile computers.

FEATURES:
PRECISION OUTPUT FREQUENCY
RUGGED
EXCELLENT WAVEFORM
SIMPLICITY OF CIRCUITRY
FAST STARTING TIME
GOOD VOLTAGE REGULATION throughout an adjustable range
ISOLATED CASE DESIGN
HIGH RELIABILITY
VIBRATION ISOLATED
COMPACT
LIGHTWEIGHT
MILITARY SPECIFICATIONS

(Send for Bulletin S-864)



PERFORMANCE SPECIFICATIONS

MODEL NUMBERS				
± .01% CPS	SIS 40311	SIS 40511	SIS 410011
± .05% CPS	SIS 40315	SIS 40515	SIS 410015
INPUT VOLTAGE	28V DC ± 10%		
MAX. OUTPUT POWER	30VA	50VA	100VA
OUTPUT VOLTAGE	115V AC (Adjustable ± 10%)		
OUTPUT FREQUENCY	400 CPS ± .01% 400 CPS ± .05%		
VOLTAGE REGULATION	±1% For Line Variations ±2% For Load Variations		
FREQUENCY DISTORTION	3% Maximum At Full Load		
LOAD POWER FACTOR	+0.5 to −0.5 Maximum		
MILITARY SPECS.	MIL-E-5400A & MIL-E-5272A		
AMBIENT TEMPERATURE	−55°C to +71°C when mounted to heat sink		
VIBRATION	20G 10 to 2000 CPS		
UNIT DIMENSIONS	L5" D 2 7/8" H 2 13/16"	L8" D 2 7/8" H 2 13/16"	L10" D 4 1/2" H 2 13/16"
WEIGHT (Approx.)	2 lbs.	3.5 lbs.	5 lbs.

MA **MAGNETIC AMPLIFIERS INC.**
632 TINTON AVENUE • NEW YORK 55, N.Y. • CYPRESS 2-6610
West Coast Division
136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

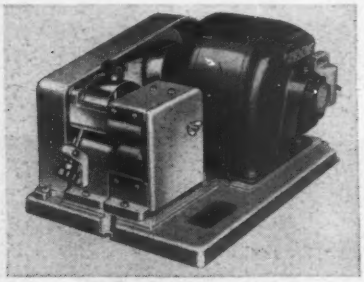
Reliable Electrical Connections

by R. George Roesch

Automatic Wire Processing with Standard Equipment

When standard equipment can be incorporated into a system for automatically stripping, fluxing and tinning coil leads, the cost of such equipment is invariably much less than that of special equipment.

The benefits of mechanizing any operation are (1) uniform quality, (2) fewer rejects and (3) lower inspection costs.



For example, using a standard wire stripper such as illustrated, we have made automatic coil lead straightening, trimming and stripping equipment for Electric Auto-Lite, Ford Motor, General Electric, Westinghouse and others. (Note: Each system was designed and built to meet the individual requirements of the user.)

A COMPLETE PROGRAM generally works out like this:

1. Your Products and Your Present Methods are studied by our engineers, without obligation to you.
2. When we are certain we completely understand your needs and wishes, a Program of Engineering and Experimental Work will be submitted. (NOTE: Nothing will be undertaken until Proven Methods have been experimentally developed.)
3. This Program will tell you (a) How Much Time will be required and (b) The Maximum Cost of Engineering and Experimental Work.
4. If you accept this program, the results must meet your own specifications. Otherwise there will be no charge made by us.
5. Assuming the experiments made prove the job can be done, we will then submit Schematic Drawings and a Quotation for your consideration on all the equipment needed to perform the desired operations.

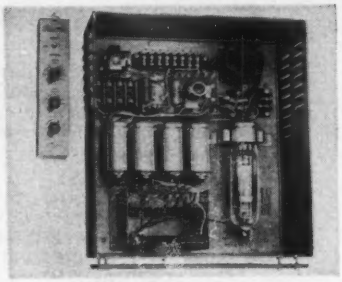
If you are making Coils in large numbers, we'd like to hear from you.

THE ERASER COMPANY, INC.
1068 S. Clinton St., Syracuse 4, N. Y.

It is said by Tin Research Institute that soldering of silver-plated contacts can be facilitated if the surfaces are first immersed in a cold solution of 8% thiourea in 5% hydrochloric acid.

CIRCLE 122 READERS SERVICE CARD

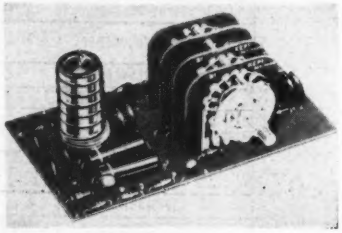
bration and noise effects far below the levels usually found in this type of equipment. **Circle 303 on Reader Service Card.**



Motor Controller operates ¾ h-p unit

GERALD K. HELLER CO., 1819 Industrial Road, Las Vegas, Nevada. The C60 electronic motor controller operates a ¾ h-p shunt wound motor on 220-230 v, 50-60 cycles single phase. Motor speed from 0-2,400 rpm, with full torque from 300 to 2,400 rpm. Controller embodies acceleration control, reverse, coarse and fine speed adjustment. It is mounted in a steel cabinet 14 in. wide by 16 in. high by 6 in. deep. The control station components are mounted in a steel box 2 in. by 2 in. by 9 in., which is connected to the controller with a special 10 conductor vinyl jacketed cable 10 ft long.

Controller price is $275; ¾ h-p motor $125. **Circle 304 on Reader Service Card.**



Rotary Switches printed-circuit type

KNIGHT ELECTRONICS CORP., 210 S. Desplaines St., Chicago 6, Ill., has developed plug-in printed circuit rotary switches for audio and r-f applications. The new switches

alumina ceramics

for electronic applications

Now you can apply the unique properties of alumina ceramics to special electronic projects:

- Low dielectric losses at all microwave frequencies.
- Extremely high mechanical strength in conjunction with thermal stability and chemical inertness.
- Can be metallized and hermetically sealed to various metals by high temperature brazing.

Frenchtown alumina ceramics are produced in a variety of sizes and geometries, either in prototype or production quantities. Dense shapes of over 200 cubic inches have been manufactured.

To engineers and scientists who wish to learn more about the capabilities and limitations of alumina ceramics, Frenchtown welcomes the opportunity to assist in the selection and proper utilization of these amazing materials. This assistance is directed toward obtaining optimum performance, simplifying complexity, reducing cost and expediting delivery.

Technical literature will be sent upon request.

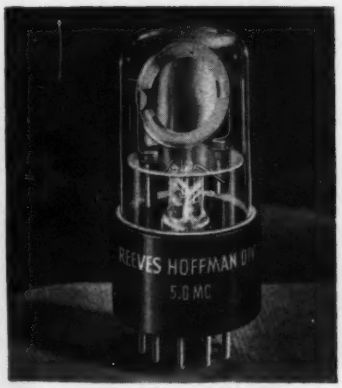
frenchtown
PORCELAIN COMPANY
FRENCHTOWN, NEW JERSEY

CIRCLE 123 READERS SERVICE CARD

have an important industrial potential in such equipment as computers, test instruments and other electronic circuits requiring multiple switching.

Consisting of a standard rotor and XXXP phenolic wafers, the switches differ from conventional rotary switches in that they eliminate manual wiring and soldering to each individual contact terminal. This saving of time and labor is achieved by using etched foil on the wafers to connect the contacts to terminal prongs on the base of each wafer.

Installing one of the switches is as simple as plugging in a tube, and dip soldering of the printed circuit board establishes all switch connections in one process. Other advantages in their use include the elimination of solder drip on switch contacts, no temper loss in contacts, no torque problem with ganged assemblies, and elimination of wiring errors. Their compactness insures maximum utilization of space. Ganged assemblies require a minimum of only ¼ in. between wafers. **Circle 305 on Reader Service Card.**

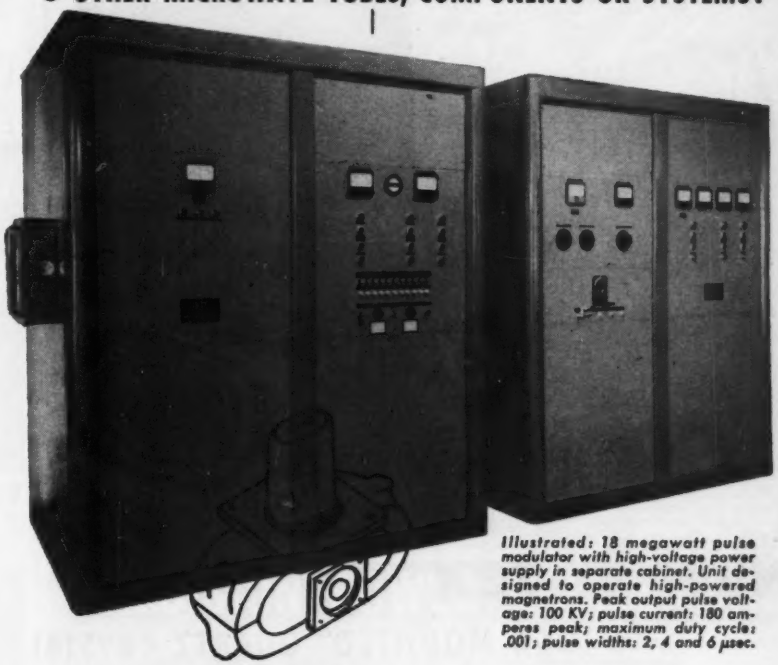


Precision Crystals meet exacting standards

Reeves-Hoffman Division of Dynamics Corp. of America, Carlisle, Pa. Manufactured to meet exacting military and commercial standards for frequency measurement, the new 5-mc high-precision crystals offer exceptionally long-term frequency stability. Frequency tolerance is held at ± 0.0001 percent and aging is only one part per hundred million parts per week. These

Testing MAGNETRONS KLYSTRONS CARCINOTRONS

● **OTHER MICROWAVE TUBES, COMPONENTS OR SYSTEMS?**



Illustrated: 18 megawatt pulse modulator with high-voltage power supply in separate cabinet. Unit designed to operate high-powered magnetrons. Peak output pulse voltage: 100 KV; pulse current: 180 amperes peak; maximum duty cycle: .001; pulse widths: 2, 4 and 6 μsec.

Come to Manson for the widest selection of standard *Pulse Modulators* and *High-Voltage Power Supplies* covering all useful power levels. From kilowatts to tens of megawatts, Manson has precision-engineered designs for operation and test of magnetrons, klystrons, traveling wave tubes, backward wave oscillators, lighthouse tubes, pulse transformers, waveguide components and related devices. The wide range of standard models is readily adaptable to meet individual specifications.

HIGH POWER PULSE MODULATORS:

Hard- and soft-tube types from 16 kw. to 30 megawatts peak power output, and higher. Average output powers as high as 60 kilowatts. Typical operating features include: continuously adjustable voltage control; discrete or variable pulse widths; internally- and externally-controllable repetition frequencies; auxiliary synchronized outputs; pulse-shape monitoring circuits; and interlocking and overload protection.

HIGH VOLTAGE POWER SUPPLIES:

High-voltage DC and AC types, single- or multiple-output, regulations and stabilities to 0.01%. Standard and custom designs to satisfy your specific tube testing or production problems: highly-regulated supplies uniquely suited for TWT test and operation; unregulated high-power supplies for systems testing; and complete power sources for controlling all aspects of tube production.

Write today for complete details on our full line of high-power pulse-test equipment and high-voltage power supplies, including applications and performance data.

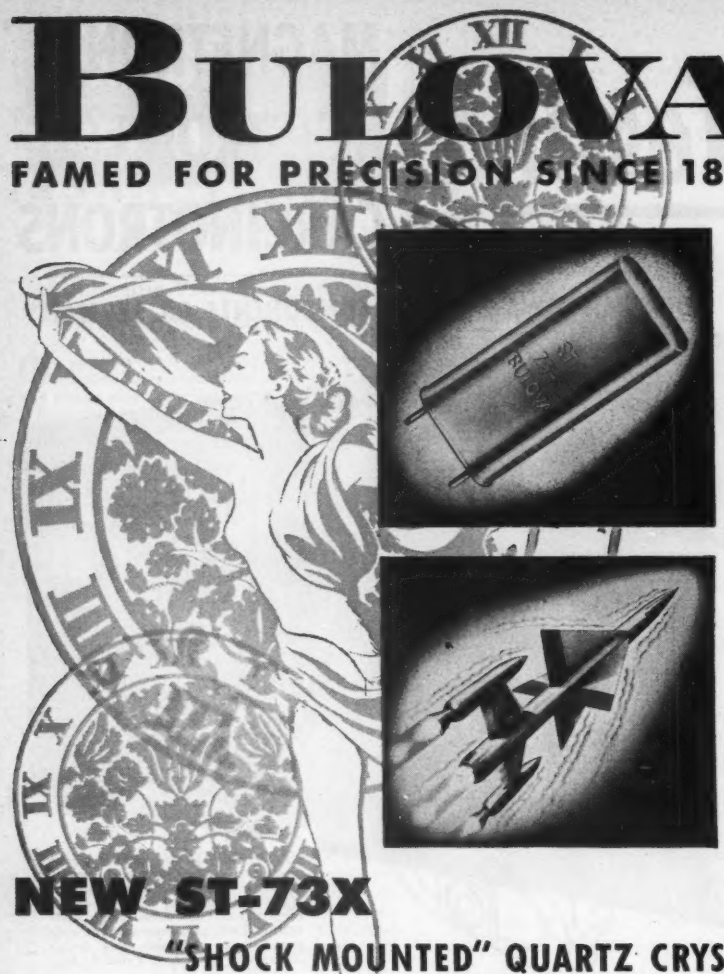
MANSON m **LABORATORIES, INC.**

207 GREENWICH AVE. manson **STAMFORD, CONN.**

Manson offers to engineers and technicians a rewarding present and attractive future in Connecticut.

BULOVA

FAMED FOR PRECISION SINCE 1875



NEW ST-73X
"SHOCK MOUNTED" QUARTZ CRYSTAL

The Bulova ST-73X need never be babied. Effective new shock mounting and traditional Bulova manufacturing precision result in a rugged, extremely stable, frequency determining element for missiles, aircraft and other applications involving extreme environmental problems.

Where frequencies must be maintained with ultra-reliable stability under high shock and temperature conditions, you'll find no adequate substitute for Bulova quality.

THE ST-73X FEATURES: Frequency Range from 16 KC through 350 KC, with lower frequencies possible in holders of different configuration; Shock Tests of 100 G; Dynamic vibration tests met per MIL-T-5422, MIL-E-5272 and MIL-E-5400 without adverse results; Storage Temperatures over a range of −65°C. to +135°C. can be coupled with an operation temperature range of −55°C. to +100°C.; Low excursions of frequency (±.015%) over this range.

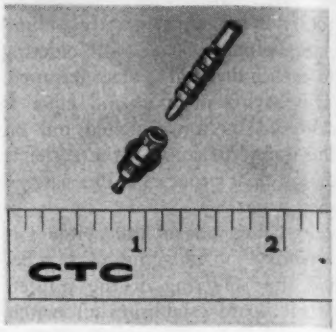
Precision Bulova Quartz Crystals are now available in quantity for frequencies from 16 KC and lower to 100 MC and above.

BULOVA
watch company

Electronics Division
Woodside 77, N.Y.

Write Dept. A-738 For Full Information and Prices on Quartz Crystals

crystals are available in hermetically sealed glass T5½ enclosures with pigtail leads on a 9-pin Bakelite base as specified. **Circle 306 on Reader Service Card.**



Plug and Jack for panel boards

CAMBRIDGE THERMIONIC CORP., 445 Concord Ave., Cambridge 38, Mass., announces a new plug and jack designed for quick, tight patch work on panel boards.

The new jack (No. 2265) assures perfect electrical connections because its gripping power is maintained by a specially-designed compression spring used with a floating key. The solder terminal is on the under side, and the jack can be obtained in shank lengths for panels varying from $\frac{1}{32}$ in. to $\frac{7}{16}$ in.

The new plug (No. 2225) is available with either a red or black nylon jacket insulation (or uninsulated, No. X2201-2). Pin length is approximately $\frac{11}{32}$ in., body length $\frac{3}{4}$ in. Mechanical connection is simple because the plug will accept up to No. 20 size wire which can be crimped around the insulation to prevent fraying; or for a solder connection, solder can be added through the window provided. **Circle 307 on Reader Service Card.**

Curing Agent for epoxy resin

LANCASTER CHEMICAL CORP., Broad & 13th St., Carlstadt, N. J. LANCAST-A is a low viscosity room temperature curing agent for epoxy resins. It has a viscosity of 600 centipoises at 80 F and can be

CABLE CLIPS

★ *of all Nylon* for severe conditions ★ *of Ethyl Cellulose* for maximum economy

WECKESSER

molded Black Nylon **SCREWS and NUTS**

★ Acid resistant ★ Need no insulation ★ Can't rust ★ Can't corrode

WECKESSER COMPANY

5701 Northwest Highway • Chicago 30, Ill.

CIRCLE 126 READERS SERVICE CARD

quality . . .
uniformity . . .
service . . .

GLASS for
HERMETIC SEALING
• EPOXY PREFORMS
• PRESSED CERAMICS

mansol CERAMICS CO.

138 LITTLE ST., BELLEVILLE, NEW JERSEY | THORNTON HEATH SURREY, ENGLAND

CIRCLE 128 READERS SERVICE CARD

★ **ULTRA LOW** *capacitance & attenuation*

TYPE	μμ F/ft	IMPED. Ω	O.D.
C 1	7.3	150	.36"
C 11	6.3	173	.36"
C 2	6.3	171	.44"
C 22	5.5	184	.44"
C 3	5.4	197	.64"
C 33	4.8	220	.64"
C 4	4.6	229	1.03"
C 44	4.1	252	1.03"

WE ARE SPECIALLY ORGANIZED TO HANDLE DIRECT ORDERS OR ENQUIRIES FROM OVERSEAS
SPOT DELIVERIES FOR U.S.
BILLED IN DOLLARS—SETTLEMENT BY YOUR CHECK
CABLE OR AIRMAIL TODAY

TRANS T RADIO

TRANSRADIO LTD. 138A Cromwell Rd. London SW7 ENGLAND CABLES: TRANSRAD, LONDON

CIRCLE 127 READERS SERVICE CARD

PRECISION POWER OSCILLATORS

PRICE **$119.00**

MODEL 1040

SPECIFICATIONS

Frequencies.....400 or 1000 C.P.S. by selector switch (other frequencies on request)
Distortion.....Less than 1 %
Hum Level.....Approximately .05 % of rated output
Output Power...3 watts into matched resistive load
Power Supply...115 volts, 60 C.P.S., 40 watts
Dimensions.....5-11/16 x 9 x 6⅛ inches

OTHER MODELS AVAILABLE

MODEL	DESCRIPTION	POWER OUTPUT
1040A	Sim. to Mod. 1040	8 watts

EXCELLENT ACCURACY AND STABILITY • TRANSFORMER ISOLATED OUTPUT • 3 OUTPUT IMPEDANCES • LOW INTERNAL IMPEDANCE • OUTPUT VARIABLE UP TO 120 VOLTS

MODEL 1500

SPECIFICATIONS

FREQUENCY.....400 CPS (Other frequencies on request)
Distortion.....Less than ½ %
Hum Level.....Approximately .02 % of rated output
Output Power.....15 watts into matched resistive load
Power Supply.....115 volts, 60 C.P.S., 120 watts
Dimension.....8¾" x 19" rack panel, 8" deep

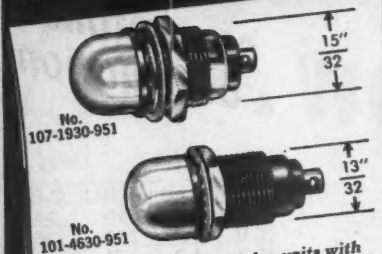
PRICE **$299.00**

Representatives in Principal Cities

INDUSTRIAL TEST EQUIPMENT CO.
55 EAST 11th STREET • NEW YORK 3, N. Y.

CIRCLE 129 READERS SERVICE CARD

PRECISION
ENGINEERED
Sub-Miniature
Pilot Lights
...facilitate the solution of miniaturization problems.



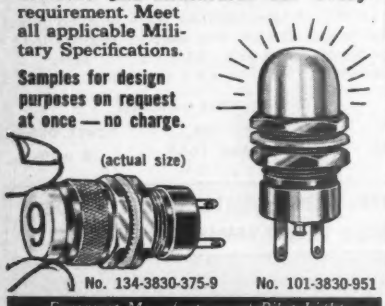
Example: Here are 2 Dialco units with but a tiny difference in o.d. of bushing: A refinement that helps to save space and weight where every fraction counts.

DIALCO

On your next miniaturization project, consult DIALCO for the Pilot Lights. You will quickly find the proper unit for use with either tiny *Incandescent bulbs (T-1¾);* or with *sub-miniature Neon bulbs (NE-2D).*

TWO-TERMINAL units are fully insulated. **SINGLE-TERMINAL** units are for use on grounded circuits. Also **DIMMING** or **NON-DIMMING** sub-miniatures for every requirement. Meet all applicable Military Specifications.

Samples for design purposes on request at once — no charge.



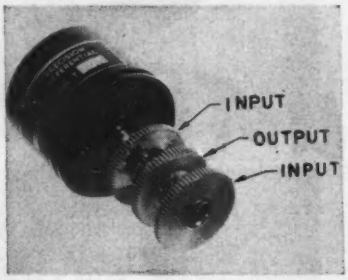
Foremost Manufacturer of Pilot Lights
DIALIGHT
CORPORATION
58 STEWART AVE., BROOKLYN 37, N. Y.
HYacinth 7-7600

Dialight Corp., 58 Stewart Ave., Brooklyn 37, N. Y.
☐ Send brochures on Sub-Min. Pilot Lights
☐ Brochures on other Dialco Pilot Lights
Name _____
Position _____
Company _____
Address _____

CIRCLE 130 READERS SERVICE CARD

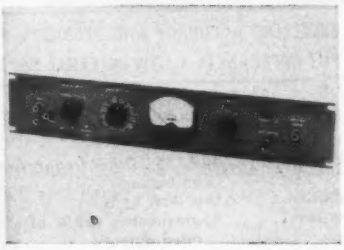
used over a wide range of ratios with all the liquid epoxy resins. The cured epoxies will vary in hardness and flexibility depending on the ratio used.

Because of its properties LAN-CAST-A should find wide use in coatings, adhesives, potting and encapsulating. **Circle 308 on Reader Service Card.**



Differential for servo and computer

Sterling Precision Corp., 34-17 Lawrence St., Flushing 54, N. Y. A completely enclosed dust-proof differential, model T-750, for high precision servo and computer applications is now available. Instead of the conventional method of having the two inputs at opposite ends of the spider, the output and inputs extend concentrically from one end of a servo mounted case. This permits mounting of this differential similar to standard servo components, thus resulting in a single line gear train. **Circle 309 on Reader Service Card.**



A-C/D-C Voltmeter priced at $650

Alto Scientific Co., 855 Commercial St., Palo Alto, Calif., has announced a new 3½ in. high transistorized voltmeter, measuring either a-c or d-c with full scale

NOW
Increased operational versatility . . greater accuracy in RF, VHF and UHF SPECTRUM ANALYSIS

with the IMPROVED
PANORAMIC PANALYZOR
MODEL SB-8b

Check these advanced engineering features:

NEW Continuously variable scanning rate from 1 thru 60 scans/sec with one control. Three selectable modes . . . free running, line synch or external synch.

NEW Three selectable types of amplitude displays . . . Square law exponential Linear 20 db, Log 40 db.

NEW Flat face CRT, edge lit calibrated screen and camera mount bezel for photographic records—optional.

NEW Differential markers to show frequency dispersion available in the Type T-10,000.

The Panalyzor Model SB-8b is available in three types, all have continuous variable sweep width and resolution;

Type	Sweep Width Range	Resolution at Reduced Sweep
T-200	0-200 kc	50 cps
T-1000	0-1 mc	200 cps
T-10,000	0-10 mc	9 kc

Write, wire, phone TODAY for detailed specifications and prices.

PANORAMIC
RADIO PRODUCTS, INC.

Send for our new CATALOG DIGEST and ask to be put on our regular mailing list for the PANORAMIC ANALYZER featuring application data.

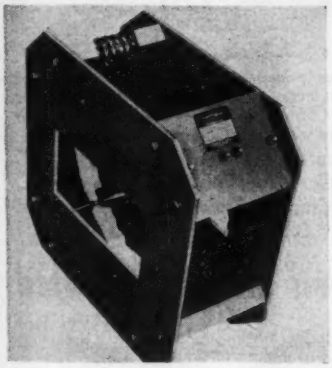
530 South Fulton Ave., Mt. Vernon, N. Y.
Phone: OWens 9-4600
Cables: Panoramic Mount Vernon, N. Y. State

CIRCLE 131 READERS SERVICE CARD

sensitivity of 1 mv.

Powered by either a 60 cycle a-c source or a built-in rechargeable battery, the model D-31 voltmeter operates on balanced or unbalanced circuits with accuracy of ±3 percent to ±5 percent on a-c and ±3 percent on d-c. Frequency response on unbalanced circuits is flat through the range 10 cps to 1 mc; on balanced circuits response is flat from 10 cps to 100 kc.

The built-in battery can be automatically recharged while the instrument is operating from a 60 cycle a-c power source. Battery life is approximately 8 hr of continuous operation; a-c power consumption is about 5 w. The instrument measures 3½ in. high by 4¾ in. deep and is the standard 19 in. width for convenient rack mounting. **Circle 310 on Reader Service Card.**

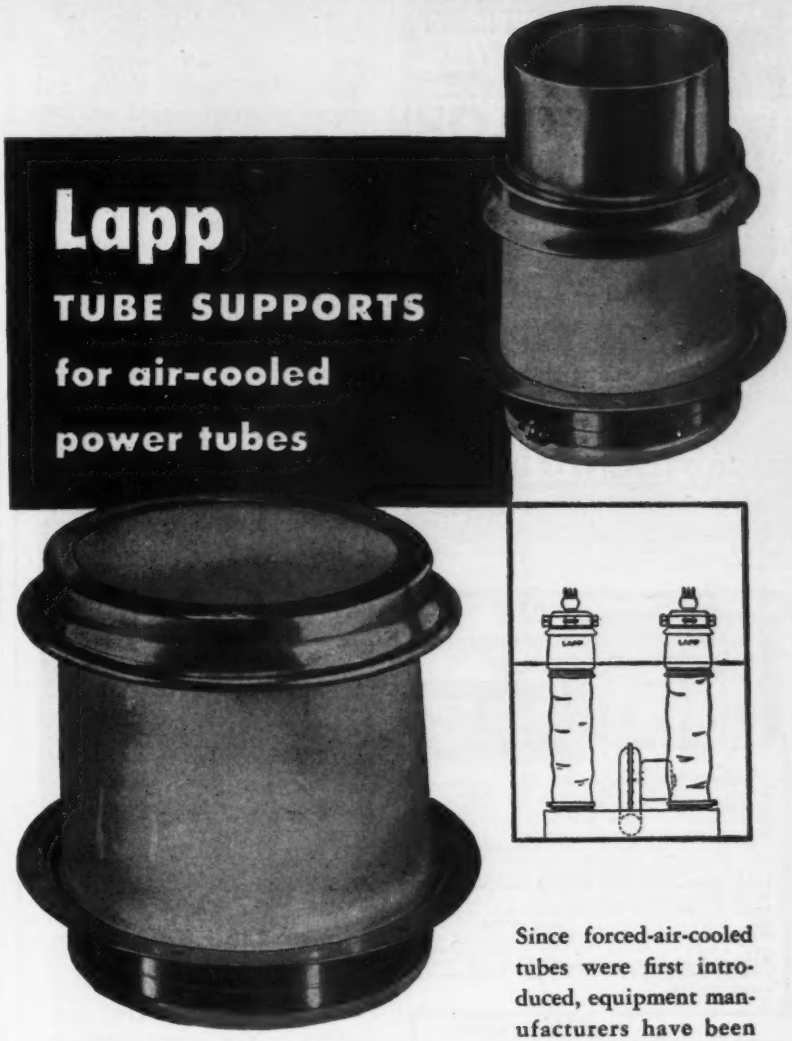


Transductors for industrial control

CONTROL, a division of Magnetics, Inc., Pittsburgh, Pa. The standardized line of transductors recently announced are used in a host of industrial control operations for measurement of large quantities of direct current without electrical connection to the systems in which they are used.

A major value of these transductors (as with the company's power reactors) is the maintenance-free longlife of the units. This results from the use of high permeability magnetic cores—virtually indestructible under normal operation. Orthonol, a nickel-iron tape Toroid registered by the parent company, Magnetics, Inc., has such square

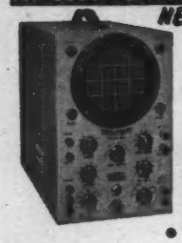
Lapp
TUBE SUPPORTS
for air-cooled
power tubes



Since forced-air-cooled tubes were first introduced, equipment manufacturers have been designing their own supports, many of which have been produced by Lapp. To standardize the great variety of tube support designs, Lapp set out to design a complete line which is now available and offers the equipment manufacturer a valuable service by way of more economical production, interchangeability and availability of replacement units. Lapp Tube Supports are compact, efficient and attractive in appearance. Their duty is threefold . . . they support the tubes, insulate, and furnish an air duct which channels air over tube fins for maximum cooling. Write for Bulletin 301, with complete description and specification data. Lapp Insulator Co., Inc., Radio Specialties Division, 139 Sumner Street, LeRoy, New York.

Lapp

the specs are the proof . . .
the BEST BUYS are EICO
for COLOR & Monochrome TV servicing

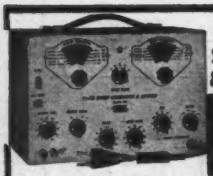


NEW COLOR and Monochrome DC to 5 MC LAB & TV 5" OSCILLOSCOPE

460 Factory-wired and tested $129.50
Also available as kit $79.95

• Features DC Amplifiers! •

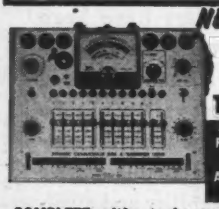
Flat from DC-4.5 mc, usable to 10 mc. VERT. AMPL.: sens. 25 rms mv/in; input Z 3 megs; direct-coupled & push-pull thruout; K-follower coupling bet. stages; 4-step freq-compensated attenuator up to 1000:1. SWEEP: perfectly linear 10 cps-100 kc (ext. cap. for range to 1 cps); pre-set TV V & H positions auto. sync. ampl. & lim. PLUS: direct or cap. coupling; bal. or unbal. inputs; edge-lit engraved lucite graph screen; dimmer; filter; bezel fits std. photo equipt. High intensity trace CRT. 0.06 usec rise time. Push-pull hor. ampl., flat to 400 kc, sens. 0.6 rms mv/in. Built-in volt. calib. Z-axis mod. Sawtooth & 60 cps outputs. Astig. control. Retrace blanking. Phasing control.



NEW TV-FM SWEEP GENERATOR & MARKER

368 Factory-wired and tested $119.95
Also available as kit $69.95

Entirely electronic sweep circuit (no mechanical devices) with accurately-biased increductor for excellent linearity. Extremely flat RF output; new AGC circuit automatically adjusts osc. for max. output on each band with min. ampl. variations. Exceptional tuning accuracy; edge-lit hairlines eliminate parallax. Swept Osc. Range 3-216 mc in 5 fund. bands. Variable Marker Range 2-75 mc in 3 fund. bands; 60-225 mc on harmonic band. 4.5 mc Xtal Marker Osc., xtal supplied. Ext. Marker provision. Sweep Width 0-3 mc lowest max. deviation to 0-30 mc highest max. dev. 2-way blanking. Narrow range phasing. Attenuators: Marker Size, RF Fine, RF Coarse (4-step decade). Cables: output, 'scope horiz., scope vertical.



NEW DYNAMIC CONDUCTANCE Tube & Transistor Tester

666 Factory-wired and tested $109.95
Also available as kit $69.95

COMPLETE with steel cover and handle.

SPEED, ease, unexcelled accuracy & thoroughness. Tests all receiving tubes (and picture tubes with adapter). Composite indication of Gm, Gp & peak emission. Simultaneous sel of any 1 of 4 combinations of 3 plate voltages, 3 screen voltages, 3 ranges of continuously variable grid voltage (with 5% accurate pot). New series-string voltages: for 600, 450, 300 ma types. Sensitive 200 ua meter. 5 ranges meter sensitivity (1% shunts & 5% pot.) 10 SIX-position lever switches: free point connection of each tube pin. 10 push-buttons rapid insert of any tube element in leakage test circuit & speedy sel. of individual sections of multi-section tubes in merit tests. Direct-reading of inter-element leakage in ohms. New gear-driven rollchart. Checks n-p-n & p-n-p transistors: separate meter readings of collector leakage current & Beta using internal dc power supply. CRA Adapter $4.50

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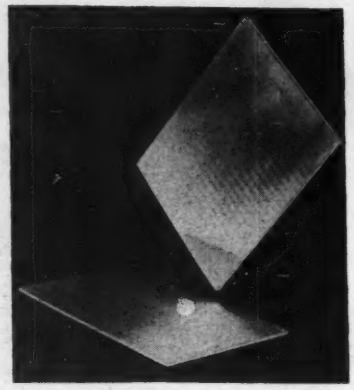
CIRCLE 133 READERS SERVICE CARD

loop characteristics that accuracy of the transductors is within ± 1 percent of rated output over the complete operating range.

The line consists of nine units, 6 for 120-v and 3 for 240-v ranging in capacity from 200 to 10,000 amperes. Accuracy of current measurement is to within ± 1 percent, even with up to ± 10 percent voltage variation and significant burden additions. Meter reduction extends from 2 amperes in the largest size to 50 ma in the smallest. **Circle 311 on Reader Service Card.**



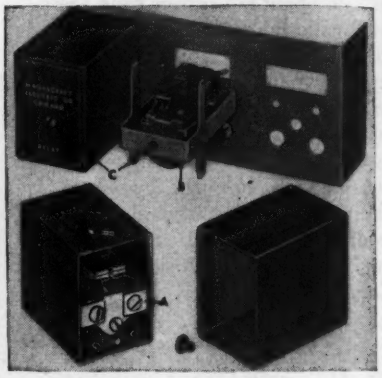
Copper Clad Teflon used in printed circuits

FLUOROCARBON PRODUCTS, INC., Camden 1, N. J., is now marketing copper clad Teflon sheet and tape for use in printed circuit applications.

The new product was designed to meet the needs of the electronic industry where a printed circuit material with a low dielectric constant, dissipation factor and water absorption is required. Besides having all of the properties associated with Teflon, this material, under duress, assures a uniform dielectric constant over a given area and no delamination of insulating material is possible.

Exhibiting strength and temperature ranges heretofore not available in printed circuits, the new material is available in 18 by 36 in. sheets ranging in thickness from $\frac{1}{32}$ to $\frac{1}{8}$ in., with 1 or 2 oz copper on both sides. Tapes range from 12 in. wide to 150 in. in length with thicknesses available from

removable dust covers for Class 22 Relays when strip, panel or chassis mounted

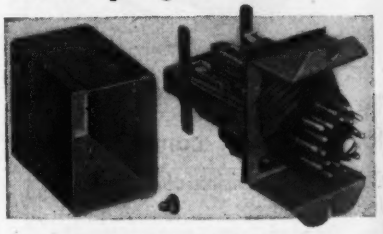


Enclosure No. 45-174

Relay mounting screws (A) attach relay and enclosure support frame (B) to strip, panel, or chassis. Dust cover fits over frame and is secured with screw (C).

Available with Class 22 Relays, AC or DC, contact combinations to 6PDT, also Class 22 Twin Contact, 22S Time Delay, 22R and 22D Power Relays.

when plug-in mounted



Enclosure 45-176

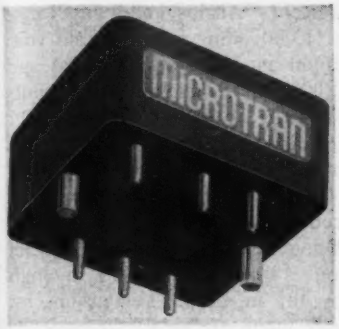
Enclosure support frame is assembled with relay and hold-down bracket. Dust cover fits over frame and is secured with screw. Mounts in any position — no hold-down clamp required.

Available with 8-, 12-, or 20-pin Octal Style phenolic plugs, AC or DC Relays; contact combinations to 6PDT, also Class 22T Twin Contact, 22S Time Delay, 22R and 22D Power Relays. *Send for literature.*

MAGNECRAFT Electric Company
3350B W. Grand, Chicago 51, Ill.

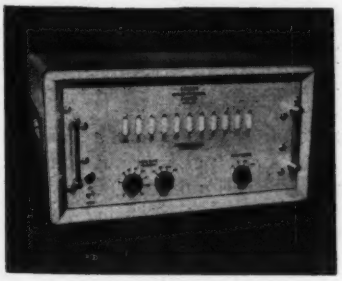
CIRCLE 134 READERS SERVICE CARD

0.005 to 0.060. The tapes can be had with 1, 2 or 3 oz copper on one or two sides. **Circle 312 on Reader Service Card.**



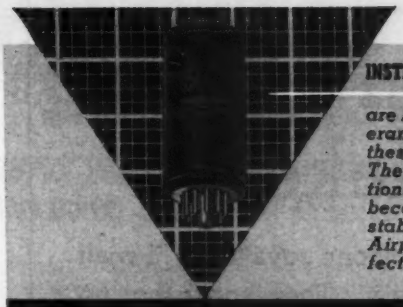
Molded Transformers microminiature

MICROTRAN CO., INC., 145 E. Mineola Ave., Valley Stream, N. Y. Designed for transistor, audio and servo applications, a new line of microminiature transformers are molded of high temperature epoxy to provide protection against extremes in ambient. Weighing ½ oz, dimensions of the MM-M series is 1¾ in. by ⅞ in. by ½ in. high. Mounting is by means of standard channel ears, threaded studs, or inserts. Terminal pins are arranged for use with dip soldered printed circuitry. **Circle 313 on Reader Service Card.**



Encoder analog-to-digital

ANDROMEDA, INC., 3742 Howard Ave., Kensington, Md. Analog-to-digital conversion of up to 2,000 codes per sec may be obtained with model 2KB Edacon encoder. The code is binary having 10 bits plus sign. Code accuracy is 1 part in

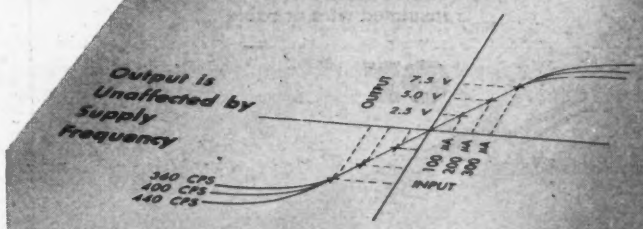


INSTRUMENT-TYPE MAGNETIC AMPLIFIERS

are being held to closer production tolerances than previously so as to make these units even more useful to you. They are used in the computing portions of high-performance instruments because of their unusual linearity and stability. Transfer Characteristics of Airpax Ferrac amplifiers are little affected by supply voltage or frequency.

DC to DC Magnetic Amplifier for Precision Instruments

As with all magnetic amplifiers, Ferrac amplifiers operate directly from the AC generator thereby eliminating the weight of DC power supplies necessary with vacuum tube or transistor amplifiers. The two input control windings are fully insulated from each other, from the power, and from the output. Thus the amplifier can be used with signals that require floating grounds.



AMPLIFIER CHARACTERISTICS

INPUT: Two independent control windings.
OUTPUT: Unfiltered DC linear ± 7.5 DC volts into 1000 ohms.
GAINS: Typical full-scale inputs are: 75 μa, 150 μa, or 300 μa.
ENVIRONMENT: Ferrac amplifiers are rated for operation − 55 C to + 85 C, vibrations of 10G at 10 to 2000 CPS, 30G shoke of 11 mspc duration. Units are hermetically sealed.

DESIGNERS AIRPAX PRODUCTS COMPANY ENGINEERS

Airpax Products Company, Seminole Division, Fort Lauderdale, Florida

"We Didn't Know You Make It"

Every now and then someone says to us, "I wish I had known you make it". They know that no other wire or cable is superior to Synkote in quality and performance.

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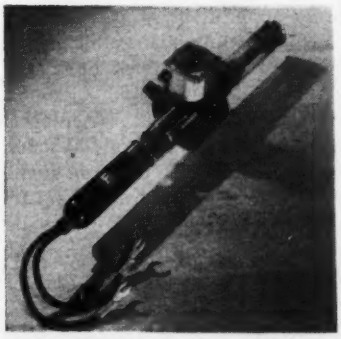
2,048 or ± 0.025 percent. Maximum bit rate is 22,000 per sec.

The unit features built-in integral power supplies which include a reference voltage source of ± 0.005 percent stability. Drift of the comparator is less than ± 0.001 percent. Analog input impedance is 1,000 ohms per full scale volt. Input ranges are 1, 10, 100 and 1,000 v. Parallel coded outputs are at 115 v, 10 ma for each of 11 outputs. Coded serial output is at 30 v 10 ma.

Internal and external bit and coding rate control are provided. Dimensions of encoder in cabinet are 21½ in. wide by 11½ in. high by 14¾ in. deep. Dimensions for rack mounting are 19 in. wide by 8¾ in. high by 14½ in. deep. Power requirements are 117 v ± 10 percent, 60 cps ± 2 cps, 250w. **Circle 314 on Reader Service Card.**



X-Band Magnetron a one megawatt unit

FERRANTI ELECTRIC, INC., 30 Rockefeller Plaza, New York 20, N. Y. The type VF-10 X-band magnetron is capable of producing 1 megawatt pulse output at mean power levels up to 1,000 w, on frequencies in the range 9,000-9,500 mc. Its overall length is 12.5 in.

The high mean power is made possible by the use of a special cathode with bombardment heating, involving an electron gun operating at 5 kv with 30 ma beam current. Standard tubes can be supplied with ±20 mc of specified frequency in the range 9,000-9,500 mc, or closer by special arrangement. **Circle 315 on Reader Service Card.**

MODERN COIL EQUIPMENT

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MODERN COIL HANDLING

Insure perfection in

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FOR READY ACCESS TO ACCURATE
FREQUENCY CALIBRATION

FULLY TRANSISTORIZED SELF POWERED
FREQUENCY STANDARD

10 KC, 100 KC, 1 MC. Frequency Stability, ±.002% to +50° C.

$125.75

- Completely transistorized
- Fundamental outputs at 1 MC, 100 KC and 10 KC
- High accuracy to +70° C
- Self powered by batteries
- Very low power drain
- Extremely portable
- Harmonic content usable beyond 200 MC
- Built-in modulation
- Printed circuit construction
- Multipurpose frame-handle

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VAN NORMAN INDUSTRIES, INC.
MANCHESTER, NEW HAMPSHIRE

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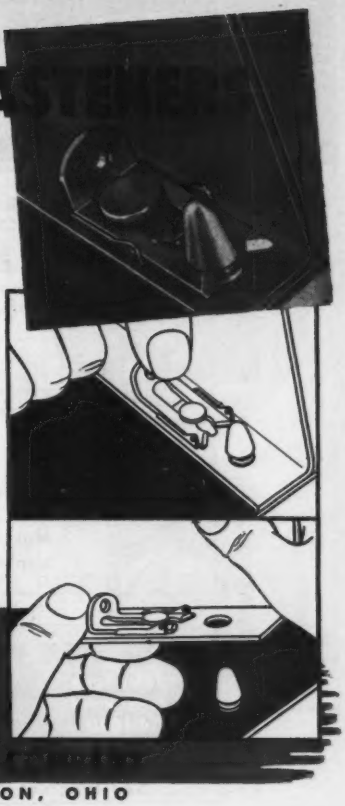
SNAPSLIDE FASTENERS

PROVIDE VIBRATION-PROOF HOLDING AND QUICK, FOOL-PROOF RELEASE!

APPROVED UNDER ARMY-NAVY STANDARDS

Here's a simple, easy means of securely fastening assemblies to withstand shock or vibration, *and yet allow quick removal for inspection or repair.* Instant snap action engages or releases fastener . . . no tools are required! After installation, fasteners never need adjustment . . . even with repeated use.

Three sizes available for different load requirements. Large and medium sizes are made of corrosion-resistant *stainless steel.* Small size is made of nickel-plated brass. Stock parts fit various thicknesses of flanges and mounting plates . . . special parts can also be supplied.



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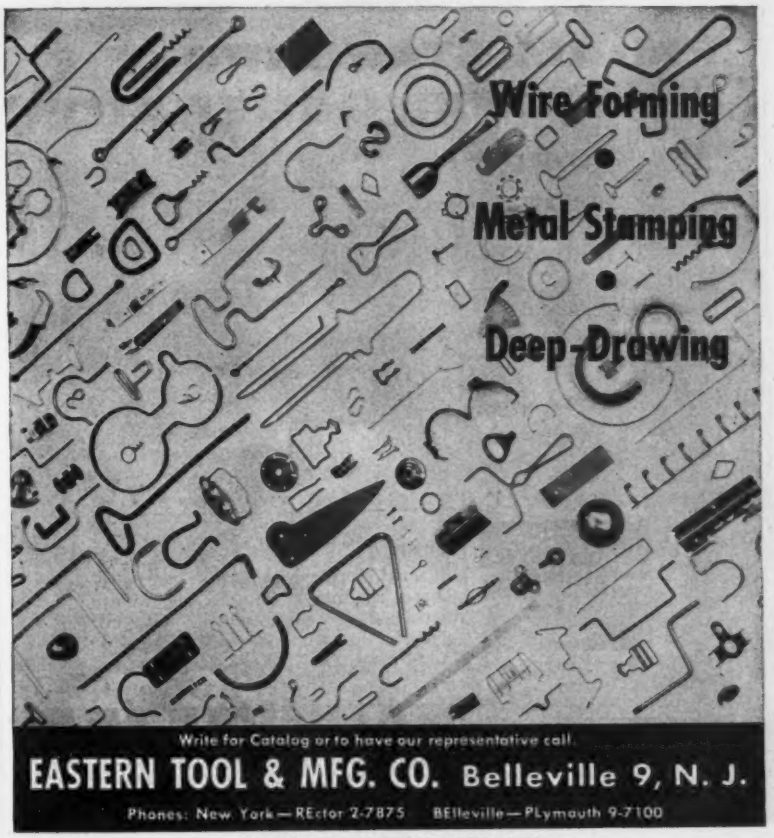
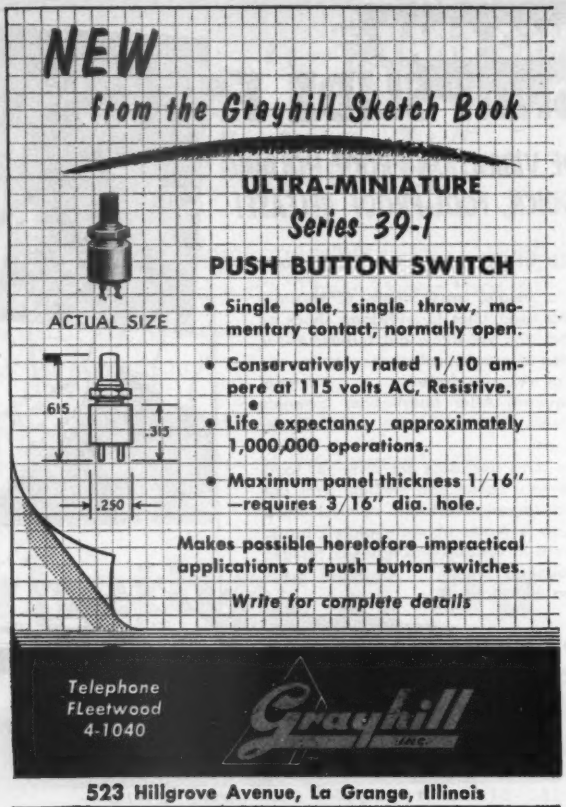


Write for Catalog or to have our representative call.

EASTERN TOOL & MFG. CO. Belleville 9, N. J.

Phones: New York—REctor 2-7875 BElleville—PLymouth 9-7100

CIRCLE 140 READERS SERVICE CARD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ULTRA-MINIATURE
Series 39-1
PUSH BUTTON SWITCH
ACTUAL SIZE
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• Single pole, single throw, momentary contact, normally open.
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Makes possible heretofore impractical applications of push button switches.
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FM-AM STANDARD-SIGNAL GENERATOR

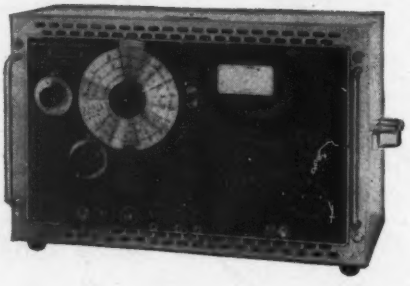
Type **MS27**

0.3—240 Mc/s in 5 ranges

FM:
Normal: ± 5, ± 25, and ± 75 kc/s ranges
High: ± 75, ± 150, ± 300, and ± 600 kc/s depending on frequency range.

AM:
0—80%

DISTORTION:
<2% at ± 75 kc/s FM
<5% at 50% AM



OUTPUT: 0.1 μV to 0.1 V across 50 or 75 ohms in 1 dB steps • Crystal calibration of dial • Direct reading ± 50 kc/s Incremental Frequency dial • Simultaneous FM and AM • Rugged militarized construction (NATO K114 specs.).

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New Literature

MATERIALS

Plastics File. Bakelite Co., Division of Union Carbide Corp., 30 E. 42nd St., New York 17, N. Y. The 1958 edition of the "Condensed Reference File" describes in easy, readable terms the major families of plastics produced by the company. The 12-page booklet is profusely illustrated and has thumb-indices to aid in finding data. **Circle 351 on Reader Service Card.**

COMPONENTS

Constant Voltage Transformers. Sola Electric Co., 4633 W. 16th St., Chicago 50, Ill. CVF-269 is a factual, illustrated four-page folder describing constant voltage transformers for electron tube 6.3 v filament supply. **Circle 352 on Reader Service Card.**

Magnetic Tapes. Minnesota Mining and Mfg. Co., 900 Bush St., St. Paul 6, Minn. Magnetic tapes for instrumentation recording are covered in an 8-page illustrated booklet. **Circle 353 on Reader Service Card.**

Microminiature Connectors. De-Jur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. A 4-page technical brochure gives specifications, diagrams and general information on an expanded line of microminiature connectors. The units described meet MIL-C-8384 specs and are ruggedized. **Circle 354 on Reader Service Card.**

Snap-Acting Switches. Hetherington, Inc., Delmar Drive, Folcroft, Pa. Standard definitions for snap-acting switches recently adopted by NEMA are given full illustrated treatment in a new folder. **Circle 355 on Reader Service Card.**

Switch Catalog. Sargent Electric Corp., 630 Merrick Road, Lynbrook, N. Y. Catalog 100-1 de-

of the Week

scribes a complete line of toggle and trigger switches. Ten types are listed with illustrations, dimensional and electrical rating data. **Circle 356 on Reader Service Card.**

EQUIPMENT

Magnetic Tape Recorder. Ampex Corp., 934 Charter St., Redwood City, Calif. An 8-page brochure introduces a new magnetic tape recording instrument which puts pictures on tape, retransmits or stores them with complete retention of original fidelity. Called Faxtape, the machine described is used in conjunction with conventional facsimile equipment. **Circle 357 on Reader Service Card.**

Memory Systems. Daystrom Inc., 5640 LaJolla Blvd., LaJolla, Calif. Technical bulletin 104 covers transistorized magnetic core memory systems. The systems discussed have storage capacities varying anywhere from 500 bits to 40,000 bits, with typical access times of from 10 to 20 μsec. **Circle 358 on Reader Service Card.**

Ultrasonic Cleaners. The Narda Ultrasonics Corp., 122 Herricks Road, Mineola, L. I., N. Y., has available a data sheet describing the SonBlaster series 600, a mass-produced line of high capacity, production-size ultrasonic cleaners. **Circle 359 on Reader Service Card.**

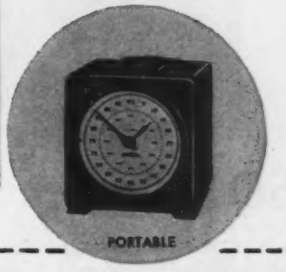
FACILITIES

Printed Circuit Facilities. Electralab, Inc., Industrial Center, Needham Heights 94, Mass. Stressing the role played by research and development, as well as quality control, in the production of printed circuitry, a 4-page brochure outlines the physical and engineering facilities which contribute to the excellence of circuits used in missiles, computers, data processing equipment, radar and quality instruments. **Circle 360 on Reader Service Card.**

precision timers by... STANDARD TRADEMARK

Industry's preferred "instrument of a thousand uses". Accurate, rugged, versatile STANDARD Elapsed Time Indicators. Synchronous motor drive. Electric clutch controlled by manual or automatic switch or output of electronic tubes. Manual or electric zero reset. Units for flush panel mounting or portable use.

Model	Scale Divisions	Totalizes	Accuracy
S-100	1/5 sec.	6000 sec.	±.1 sec.
S-60	1/5 sec.	60 min.	±.1 sec.
SM-60	1/100 min.	60 min.	±.002 min.
S-10	1/10 sec.	1000 sec.	±.02 sec.
S-6	1/1000 min.	10 min.	±.0002 min.
S-1	1/100 sec.	60 sec.	±.01 sec.
MST	1/1000 sec.	.360 sec.	±.001 sec.
MST-500	1/1000 sec.	30 sec.	±.002 sec.



Request Bulletin No. 198.

THE STANDARD ELECTRIC TIME COMPANY
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FLUSH LATCH

Whether you are designing a cabinet or planning to improve your present one . . . Missile-Air flush latches are the best in quality, performance, and trouble free in operation.

Ruggedly made of stainless steel, except for aluminum alloy buttons, our flush latches are easy opening, positive sealing, light weight, simple to operate and install.

it's the KEEPER that counts!

Missile-Air

For further information and literature, contact our Engineering Department.

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SDC Plants Will Serve AF

A $20 MILLION Air Force contract has just been transferred from the RAND Corporation to the newly organized System Development Corp. (Santa Monica, Calif.), an independent non-profit corporation, as is RAND. Under the contract, SDC will provide professional technical services to the Air Defense Command. The new corporation, using the facilities and personnel of the former System Development Division of RAND, will continue to work closely with RAND. According to RAND's president, F. R. Collbohm, it was found desirable to set up SDC as a separate corporation with the rapid expansion of System Development Division's activities. RAND serves mainly in a scientific advisory capacity on long-range research for the Air Force.

SDC employs more than 1,800 people, including highly-trained specialists from psychologists to computer programmers. Work is being done on two major projects related to Air Defense. One project involves the development, installation, and maintenance of a System Training Program simulating emergency situations, such as enemy raids on U. S. targets, to give the air defense system practice. The program helps the Air Defense Command to develop flexible adaptation to any emergency.

SDC's second big job is programming for SAGE (Semi-Automatic Ground Environment) air defense system computers. SAGE, soon to operate throughout the U.S., uses a network of huge hi-speed electronic digital computers to process data about the 30,000 plane flights taking place daily in the nation. The computers, connected directly to radars, weather stations, etc., sift, display and transmit constant reports on the air traffic picture. Radar detection of aircraft is correlated to all other information by the computer. In the case of "unknown" aircraft, interceptors are accurately guided to the craft with exact information on speed, altitude, and direction. The computers can also serve to launch and guide missiles.

Beside the main location in Santa Monica, SDC has a group at Lexington, Mass., where SAGE originated. SDC representatives are also stationed permanently at major Air Defense Command centers throughout the nation, and traveling teams of programmers set up new programs at the different SAGE computing installations.

Earnings from contracts are used by SDC to further research in the interests of security and public welfare.

In Santa Monica, SDC occupies a new 110,000 sq ft office and equipment building, plus a 60,000 sq ft structure (right foreground in the picture) housing a modified SAGE computer for developing and checking computer programs before they are taken to SAGE sites. A third office building, 130,000 sq ft, (at left in the aerial view) has just been completed and is being occupied.

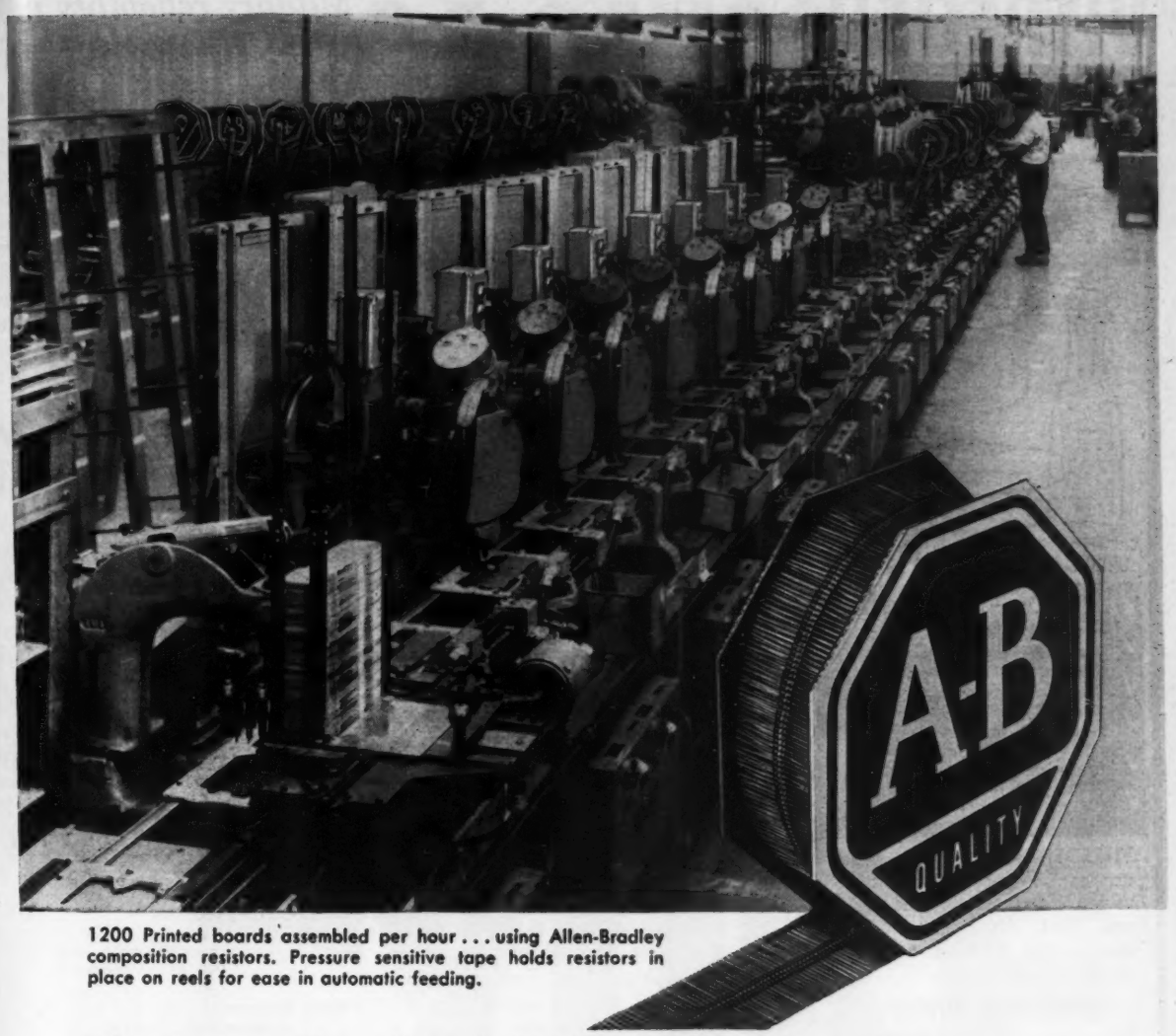
AIL Names Chief Engineer

PROMOTION of Lawrence J. Torn (picture) to the position of chief engineer of Airborne Instruments Laboratory, Inc., Mineola, N. Y., is announced. His new work assignment calls for coordination of the company's production design activities in the field of industrial control systems involving automatic machine and process controls and electronic test equipment.

Torn's experiences with AIL have been in the fields of servomechanisms, feedback amplifiers, analog computers and closed-loop radar data processing systems. They include responsibility for engineering development as project engineer of a large-scale radar data processing system that incorporated new concepts of theory and circuitry.

Paragon Plans Consolidation

GROUND has been broken in Two Rivers, Wisc., on a new $400,000 manufacturing plant for Paragon



1200 Printed boards assembled per hour . . . using Allen-Bradley composition resistors. Pressure sensitive tape holds resistors in place on reels for ease in automatic feeding.

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Allen-Bradley's exclusive process used in making its solid molded resistors assures dimensional uniformity that is astounding. Consequently, their use in mechanized assembly virtually eliminates costly shutdowns to clear jammed stations resulting from "off-size" units. The clean, tough surface of A-B molded resistors will withstand mechanized handling without chipping or cracking. Since wax is *not* used to provide moisture resistance, this source of trouble is also eliminated. Differentially tempered leads permit bending without wire breakage.

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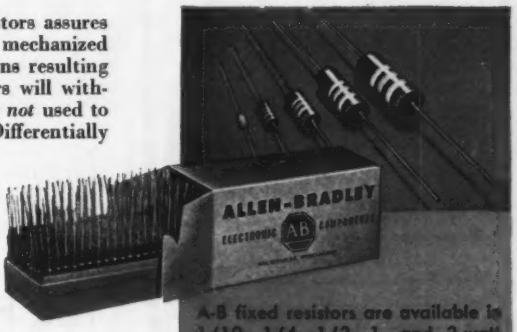
ALLEN-BRADLEY
A-B fixed resistors are available in 1/10, 1/4, 1/2, 1, and 2-watt sizes, in all RETMA values. Also carton packed for manual assembly.

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CIRCLE 145 READERS SERVICE CARD

Electric Co., makers of automatic time controls. The 72,000-sq ft plant will enable the company to consolidate all the manufacturing operations of its five separate plants at a single site.

Consolidation of manufacturing operations and expansion of facilities is expected to result eventually in employment of over 500 people.

Perkin-Elmer Fills Key Post

NEW general manager of the instrument division, Perkin-Elmer Corp., Norwalk, Conn., is R. Victor Harris (picture). He succeeds Van Zandt Williams, who was recently named executive vice president of the company.

Harris joined Perkin-Elmer in 1949 and became director of production in 1950. When the instrument division was formed in 1956 he became its assistant division manager and held this position until his new appointment.

Prior to Perkin-Elmer, he was associated with Taylor Instrument Co. and MIT. During the war he was a staff research engineer at the MIT Radiation Laboratory where he worked on radar gun directors.

IRE Honors Roberts

FRANK B. ROBERTS, chief engineer for communications receivers and components, National Co., Inc.,

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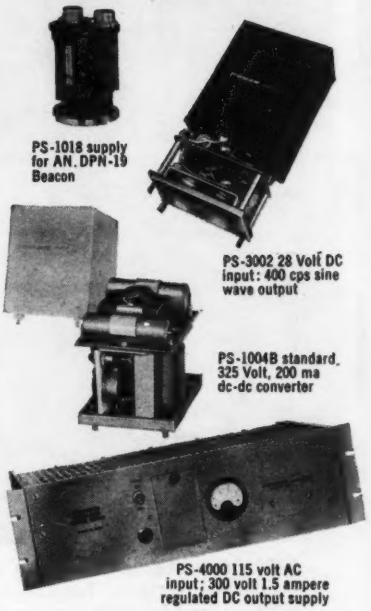
SEMI-CONDUCTOR POWER CONVERTERS



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Malden, Mass., received an award from the professional group on broadcast and tv receivers of the IRE for contributing the outstanding recent paper in the field of interest of this professional group. The award was made by Harlan A. Bass, Director of Radio & Television Engineering, Avco Mfg. Corp., Cincinnati, Ohio, at the Radio Fall Meeting of the IRE group in Toronto.

Westinghouse Ups Frailey

NEW operations manager for power and special purpose tubes at Westinghouse electronic tube division is Henry F. Frailey. He will be responsible for the design, development, engineering and manufacturing of these tubes.

Frailey has been with the division since 1951, first as a supervisor of manufacturing engineering and then as superintendent of the crt department. Prior to joining Westinghouse, he was associated with Sylvania and RCA.

Offers New Service

A PROCUREMENT service organization known as R. G. Expediters Service has been opened at 220 Fifth Ave., New York, N. Y. Founder is Robert Gueydan (picture), formerly assistant director of purchases, Remington Rand Div., Sperry Rand Corp.; and procurement representative of Convair, a division of General Dynamics Corp., respectively.

The new firm plans to offer a

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Exclusive Gries techniques actually improved design and performance by die-casting this zinc-alloy threaded shaft and injection-molding the mating Nylon nut. Both units formerly were produced as screw machine parts, at 5 times the present cost. A typical demonstration of GRC's unique talent for doing big things with small parts . . . economically!

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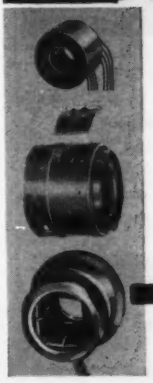

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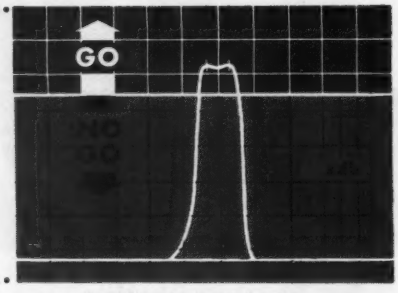

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procurement expediting service functioning for purchasing departments everywhere whose suppliers are located in the eastern United States. Gueydan will call on vendors in person, outline problems and circumstances for purchases and make facilities surveys and plant or vendor evaluations in all branches of industry and manufacturing.

According to Gueydan, many companies now find that they have orders that are being processed far too slowly or they find improved delivery dates imperative. Many also require more factual information on the status of their orders and the facilities of their suppliers. He believes this service can serve purchasing departments more economically than they themselves can perform this function with their own personnel.

Dalmo Victor Forms Division

A NEW electronic systems division has been formed by Dalmo Victor Co., Belmont, Calif. It will be responsible for engineering, manufacturing, and sales of electronic systems, test equipment and subassemblies. Present Dalmo Victor work in these fields includes sonar, magnetic detection, communications, countermeasures and infrared.

Glenn A. Walters (picture), formerly vice president in charge of research, will direct the new division as vice president and manager. Walters, who joined Dalmo

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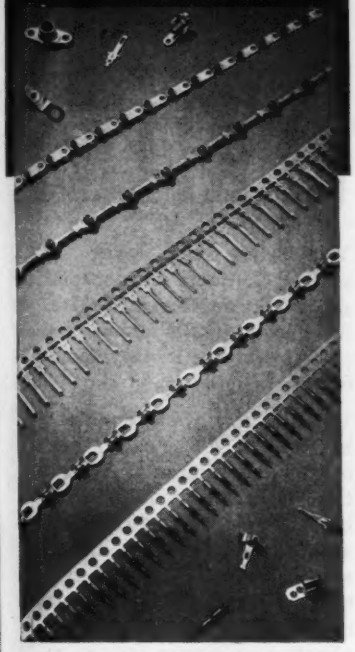

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Victor in 1947 as an electrical design engineer, was appointed director of research in 1950, in which capacity he headed a laboratory staff of 75. In February 1957, he was named a vice president of the firm.

He has pioneered the development of miniaturized electronic packages and circuit simplifications for airborne electronic equipment manufactured by the company.

ESC Hires Peressini

APPOINTMENT of Richard D. Peressini (picture) as project engineer at ESC Corp., Electronic Components Division, Palisades Park, N. J., is announced. He was formerly an associate engineer in the transformer department of Allen B. Du Mont Laboratories.

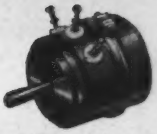
In his new capacity at ESC, Peressini will be engaged in the design and development of the company's line of custom-built and stock pulse transformers, pulse-forming networks and miniature plug-in encapsulated circuit assemblies.

Plastics Firm To Expand

NORTHWEST Plastics, Inc., St. Paul, Minn., is already planning to double the size of its recently built facility at Gastonia, N. C.

The subsidiary factory, called

This precision Potentiometer easily withstands



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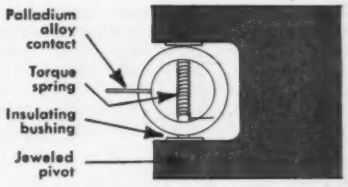

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SIZE	Threads Per Inch	Major Diam.	Pitch Diam.	Minor Diam.	Pitch	Depth of Thread
000	120	0.034	0.0286	0.0260	0.00833	0.00400
00	90	0.047	0.0403	0.0326	0.01111	0.00721
0	80	.060	.0519	.0438	.01250	.00812
1	72	.073	.0640	.0550	.01389	.00902
2	56	.086	.0744	.0628	.01786	.01160
3	48	.099	.0855	.0719	.02083	.01353
4	40	.112	.0958	.0795	.02500	.01624

SIZE	Head Diam.	Height of Head	Depth of Slot	Width of Slot	Tap Drill	Body Drill
000	.056	.031	.014	.012	#71 (.026)	#63 (.037)
00	.068	.038	.014	.023	#65 (.035)	#55 (.052)
0	.090	.050	.022	.025	3/64 (.047)	#51 (.067)
1	.111	.062	.024	.027	#53 (.059)	#47 (.078)
2	.132	.073	.029	.030	#50 (.070)	#42 (.093)
3	.153	.084	.035	.032	#47 (.078)	#37 (.104)
4	.174	.096	.040	.034	#43 (.089)	#31 (.120)

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Northwest Plastics of Carolina, Inc., is operating at near capacity with 50 employees. Plans call for a 10,000 sq ft addition to the Gastonia plant which turns out electrolytic capacitor enclosures.

J. R. Freyermuth, president of the parent company in St. Paul, looks for ground to be broken in the very near future. The initial $225,000 factory was so designed on its 11-acre site that it could be enlarged on any of its sides.

Molded Parts Maker Expands

GENERAL PRODUCTS CORP. (picture) of Union Springs, N. Y., manufacturer of terminal boards, cable assemblies and precision molded parts for industrial and government applications, has completed an extensive plant expansion program which increases its floor space over 2½ times the original area.

The new area will house the sales and engineering staff, general offices, additional production areas and a new laboratory. Facilities gained by the plant expansion program allows a much greater range in new product design and development.

Open Testing Lab in West

UNITED ElectroDynamics, Pasadena, Calif., has opened a new facility in Monterey Park, Calif., to be called the United Testing Laboratories. The new facility encompasses 30,000 sq ft of which 7,500 sq ft will be devoted to atmospheric controlled electronic lab-

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oratories, and 10,500 sq ft additional floor space to general mechanical and environmental testing area. The spacious site allows for flexibility of indoor as well as hazardous outdoor testing.

Robert D. Fagaly, general manager, and D. L. Roelands, operations manager, head a staff consisting of 60 engineers and technicians, supported by an office staff of 10 persons.

The complete facility is available to industry on either a project performance or a long-term continuing basis.

Midwest Firm Incorporates

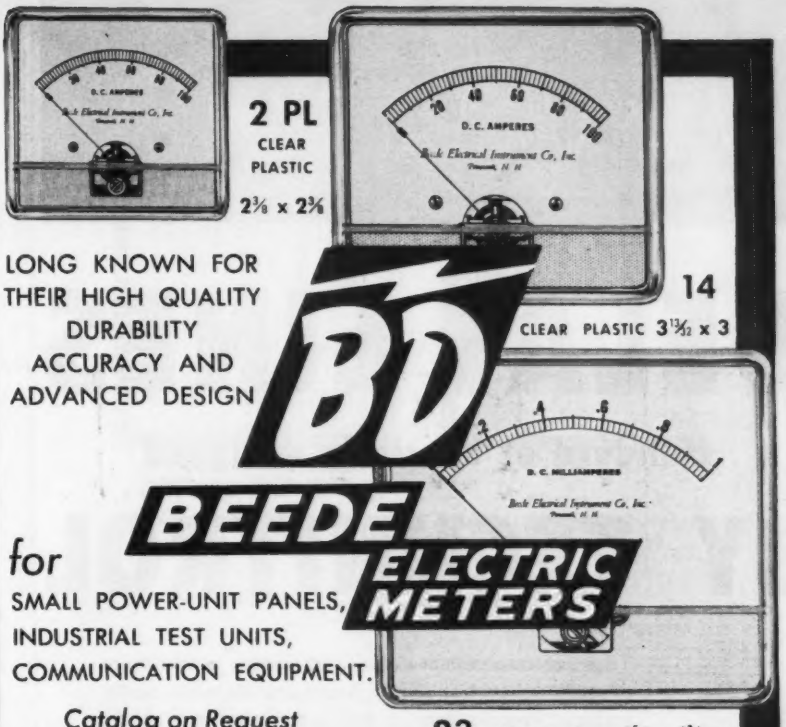
In Seymour, Indiana, Condenser Research Corp., a subsidiary of Marathon Electric Mfg. Corp. of Wausau, Wisc., was recently incorporated.

James C. Cupp has been appointed vice president and chief engineer, and Arthur B. Mayer, sales manager of the capacitor making firm.

ACF Elects V-P

Election of Henry A. Correa (picture) as vice president for foreign operations of ACF Industries, Inc., is announced. Associated with Bendix Aviation Corp. since 1945, he most recently was aviation sales manager for its International Division.

Correa will coordinate his activi-



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40C1 Carrier-Telegraph Channel Terminal (J70047C) • 140A1 Carrier Supply (J70036A1, etc.) • 40AC1 Carrier-Telegraph Terminal.

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D-C TELEGRAPH EQUIPMENT

16B1 Telegraph Repeater (J70037B) • 10E1 Telegraph Repeater (J70021A) • 128B2 Teletypewriter Subscriber Set (J70027A).

TEST EQUIPMENT

2A Toll Test Unit (X63699A) • 12B, 13A, 30A (J64030A) and 32A (J64032A) Transmission Measuring Sets • 111A2 Relay Test Panel (J66118E) • 118C2 Telegraph Transmission Measuring Set (J70069K) • 163A2 Test Unit (J70045B) • 163C1 Test Unit (J70045D).

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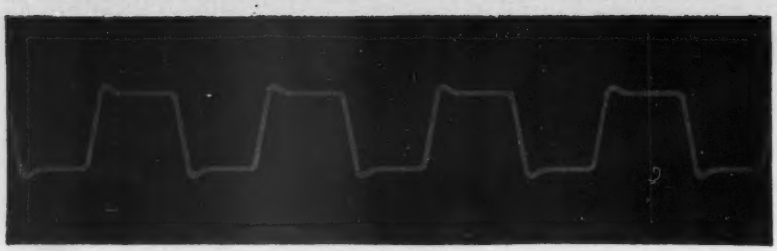

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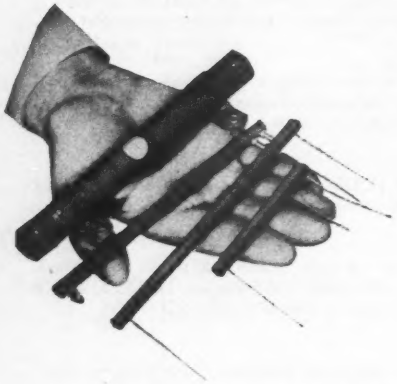

- **Delay: 0.01 to 6 μs**
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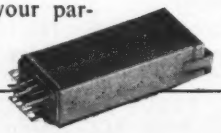
We are prepared to design lumped constant or distributed constant delay lines for your particular circuit applications.



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ties with those of the ACF operating divisions in marketing the company's products abroad, including railroad equipment, nuclear reactors, valves, flight simulators, and other training devices, electronic equipment and aircraft and missile parts and components. He will make his headquarters in New York.

Add to Filtors Staff

In Port Washington, N. Y., Filtors, Inc., manufacturer of hermetically sealed subminiature relays, adds Michael Giordano (picture) to its engineering staff.

Prior to joining Filtors, Giordano was associated with The Nagler Helicopter Co. as consulting staff engineer. His background includes an eight year association with the Grumman Aircraft Corp. as missiles design and materials engineer and as test engineer for the engine division of the Fairchild Airplane and Engine Corp.

Clevite Fills New Post

Newly created post of production manager at Clevite Transistor Products, Waltham, Mass., is taken over by Albert J. Harcher. The position was created in a move to expand production of recently announced silicon-germanium alloy diodes and

Hundreds of standard

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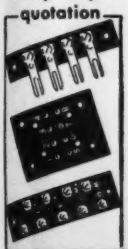

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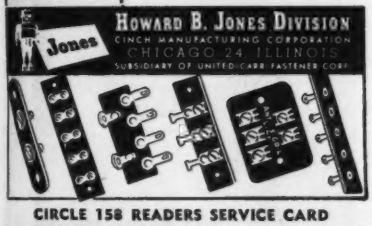

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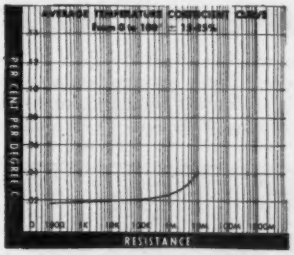
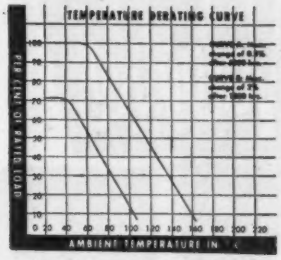
(Small Quantity)

PRECISION CARBON DEPOSITED RESISTORS



Temperature coefficient characteristics for ALPT—1 watt resistor



Derating curve for ALPT—1 watt resistor

STANDARD RESISTORS ±1% TOLERANCE IN 10% RMA VALUES FROM 10 OHMS TO 2.7 MEGOHMS

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Factory Delivery, other than stock values:
1/10, 1/5, 1/4, 1/2, 1, 2 and 5 Watt

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For Missile Testing

and general use

30 to 300 Amps

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- Rigid Quality Control

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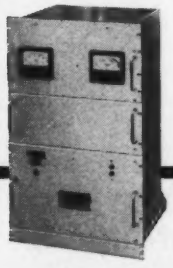
POWER RECTIFIERS

Available in Industrial and Military types. Military type meets specs MIL-E-4970 and MIL-I-6181. Other stationary and mobile styles available up to 1500 Amps.



Write for Bulletin AC-58-A

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SUB-MINIATURE HERMETIC ELAPSED TIME INDICATORS.

You, too, can afford the space to keep track of time! From now on, these really small (1¼") Elapsed Time Indicators will keep company with the best of Electronic Miracles.

The illustration shows how the operating time of various sections of an electronic console can be monitored.

The dial type units read up to 2,500 hours in one hour increments, while the digital type units read up to 9999.9 hours in one-tenth hour increments. Designed for military applications, these 4½ ounce units can save valuable panel space in industrial and electronic applications.

The 400 cycle models now in production are described in Bulletin AWH ET 602.

The A.W. HAYDON COMPANY
235 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices

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other diodes and transistors.

Harcher was formerly associated with CBS-Hytron, serving as plant manager of both Newburyport and Kalamazoo tv picture tube operations. Earlier he had served the company as temporary plant manager in Lowell, Mass., and as chief engineer in charge of developing rectangular tv picture tubes.

His professional career started with Westinghouse research laboratories. He also served as a development engineer for RCA, and as chief engineer for Lansdale Tube Co.

Fite Joins Burroughs

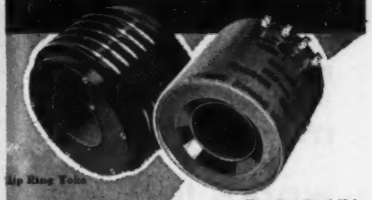
RETIRED U. S. Army Colonel, Randolph V. Fite (picture), who set up the Munich relay station for the Voice of America and developed various radar warning and tracking systems for the Army, has joined the Burroughs Corp. Research Center in Paoli, Pa. He will serve in an advisory capacity to the manager of the special products division which is responsible for research and development of secret military equipment and systems.

Aerophysics Ups Steinhoff

NEWLY appointed associate technical director at Aerophysics Development Corp., Santa Barbara, Calif., is Ernst Steinhoff.

With more than 24 years of ad-

PRECISION
DEFLECTION
WITH
COSSOR YOKES



Slip Ring Yoke

Two-Axis Fixed Yoke

Component Development Engineering at its BEST!

- ADVANCED ELECTRICAL DESIGN
- PRECISION MECHANICAL DESIGN
- ACCURATE PRODUCTION METHODS

Custom Built to the most
Exacting Specifications
by Cossor Engineers

In Mumetal Cores for Optimum Geometry
In Ferrite Cores for Speed and Sensitivity
In Non-magnetic Cores for Perfection of Response

Any of Cossor's Three Core Types can be made in single or double axis with single or push-pull windings, and encapsulated for fixed or slip ring (rotating) use.

Normal characteristics of yokes for 1-1/2 in. neck tubes are:

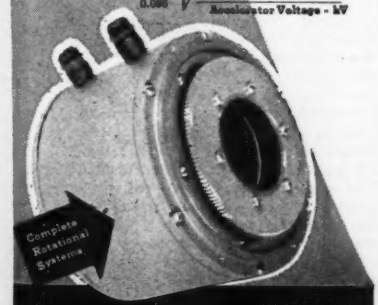
Positional accuracy - the spot position will conform to the yoke current co-ordinates within 0.25% of tube diameter. For deflection angles less than ±25° better accuracy can easily be achieved.

Memory - 0.5% max. without overswing:
0.1% or less with controlled overswing.

Complete encapsulation in epoxy (stycast) or silicone resins is standard for all Cossor deflection yokes, and is done with special moulding tools ensuring accurate alignment of the yoke axis. When slip rings are added, solid silver rings are mounted in encapsulating resin. The finished slip ring yoke is precision turned to centre bore, and can include bearing mounting surfaces with dimensional tolerances approaching those associable with high quality metal parts.

Settling Time (Micro sec.) = $\frac{}{120\sqrt{\text{Inductance in Henries}}}$

Sensitivity degrees/milliampere = $\frac{}{0.080\sqrt{\frac{\text{Inductance - millihenries}}{\text{Accelerator Voltage - kV}}}}$



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648A Yonge St., Toronto, Ont.
Corporation House, 160 Laurier West, Ottawa, Ont.

CIRCLE 164 READERS SERVICE CARD

vanced experience in aeronautical and missile engineering in the U. S. and Europe, Steinhoff has been department manager of Air Force Missile Projects at Aerophysics, a position he will retain.

Form New Firm In California

A NEW electronic systems manufacturing and development company, Moore Associates, Inc., has been founded in Redwood City, Calif. Its president is Albert L. Robinson (pictured at top) who has been a member of the research staff of Bell Telephone Laboratories for the past 21 years.

Vice president of the new firm is James B. Bullock (shown below), formerly with Electrical Communications, Ltd. of San Francisco.

Chief Engineer is Laurence Moore, until recently a project engineer with Levinthal Electronics in Palo Alto.

Moore Associates is specializing

GUDEBROD
BRAIDED
NYLON
LACING
TAPES ARE
EASY TO TIE:
WON'T SLIP—
EASY ON
THE HANDS:
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EASY TO SEE:
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Gudebrod flat braided lacing tapes hold harness securely—no bite-through or slip, yet are easy on the hands. Some resist high temperature, some are color-coded . . . and they come wax-coated or wax-free . . . rubber-coated . . . or with special coating. Gudebrod makes many tapes for many purposes, including defense work. Send us your lacing problems or your specifications . . . we can supply the answer to both.

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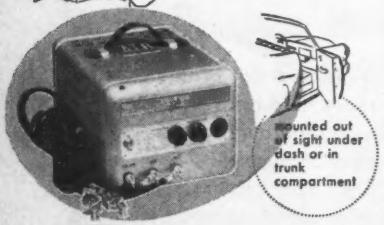

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CIRCLE 166 READERS SERVICE CARD

in the manufacture of transistorized telemetering and remote control equipment for rail, petroleum, chemical and utilities industries. The company also anticipates entry into the data reduction field at an early date.

GAC Forms an Affiliate

General Atronics Corp., Bala-Cynwyd, Pa., a consulting, research and development firm, has formed an affiliated company, Atronic Products, Inc.

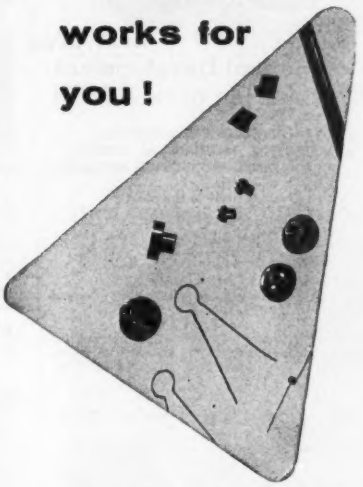
A typical equipment of Atronic Products is an automatic sequential tester, for checking printed circuit cards at the end of a production line. The prototype of the tester, recently completed by General Atronics, is capable of carrying out as many as 360 electrical tests, within two minutes, on the circuits being tested.

Elect Altec V-P To Top Post

A. A. Ward (picture) executive vice president and director of Altec Companies, Inc., has been elected president of the organization.

He worked four years for the Southwestern Bell Telephone Co. in Houston, Texas, and in 1929, joined Electrical Research Products Inc. to install and service

HOW precious metal metallurgy works for you!



The J. M. Ney Company, with more than 146 years in the highly specialized precious metal business, has gathered a wide background of information for analyzing the properties and uses of precious metal alloys and developing alloys for specific applications.

With facilities for subjecting experimental and standard alloys to a full range of physical, electrical, and metallurgical tests as well as tests simulating actual and accelerated conditions, Ney offers a valuable service to the rapidly growing electronics industry.

Coupled with the development help that Ney offers are extensive manufacturing facilities for the production of materials and small precious metal parts in either standard shapes or to customer specifications. We are also prepared to give engineering advice on general design characteristics and suggest the proper alloy for your use. Our catalog describing our proprietary alloys, line of standard contacts, resistance wires, and engineering services is available on request.

NEY

The J. M. Ney Company
P.O. Box 990, Dept. E, Hartford 1, Conn.

CIRCLE 167 READERS SERVICE CARD

theatre sound equipment. In the mid-thirties, Ward was transferred to New York in commercial engineering.

In 1937, Ward became head of specialty engineering with the newly formed Altec Service Co. When Altec Lansing Corp. was formed in 1941, he became general manager and in 1943, was elected vice president and director. In 1945 he was elected executive v-p and also v-p and director of Altec Service Co. In 1956 came the formation of Altec Companies, Inc., parent group for Altec Lansing Corp. and its divisions, with Ward being elected v-p and director. He became executive v-p for the parent company early in 1957.

Ward will maintain offices in the new Altec Lansing Corp. headquarters in Anaheim, Calif., where Altec sound equipment is manufactured.

Mundie Joins Bendix

BENDIX Aviation Corp. has appointed Lloyd G. Mundie head of the infrared department of the Bendix systems division.

Mundie will be in charge of a program devoted to research in infrared physics and the development of devices utilizing infrared radiation in the accomplishment of military and industrial objectives.

GTC Upgrades Cohen

GENERAL TRANSISTOR CORP., Jamaica, N. Y., appoints Bernard

ONE FLICK RESETS this HIGH SPEED *Electric* COUNTER

Model "YE" by

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First high-speed electrically actuated counters with added advantage of electric reset. Clean-cut, legible 3/16" figures, white on black. Ideal for all high-speed electric counting applications — accurate at high, low or intermediate speeds.

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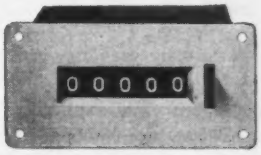
ALASKA GRAY AND SEAL BROWN



Compact, with great rigidity — entirely enclosed against dust and moisture. Base or panel mount. Speeds to 1500 C.P.M.

PRODUCTIMETERS SINCE 1879 *Count Everything*

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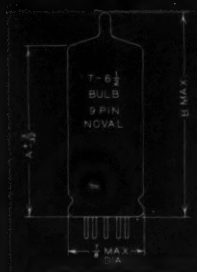
A NEW CRYSTAL UNIT WITH EXCEPTIONAL STABILITY AND PRECISION IN RANGE 4 kc TO 3000 kc

RANGE	A	B
4-85 kc	2"	2⅜"
85-150 kc	1 7/16"	1 13/16"
150-3000 kc	1⅛"	1½"

This all-glass vacuum mounted crystal unit provides maximum stability, with low effective series resistance, in the range between 4 kc and 3000 kc.

For example, in the range 800 kc to 3000 kc, stability of 4 parts in 100 million (4×10^{-8}) per day can be obtained when used with temperature control that holds ± 0.1°C. Under these conditions ageing will not exceed 2 parts in 100 million per day.

Supplied for oven or non-oven operation.



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Bliley

BLILEY ELECTRIC CO.
UNION STATION BUILDING • ERIE, PA.

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DIRECTIONAL COUPLERS

VSWR and RF POWER MEASURING EQUIPMENT

New Products included in new Catalog No. 12 create the most extensive line available.

RF POWER and VSWR INSTRUMENTS

Model No.	Frequency Range (mcs.)	Power Range Incident & Reflected (watts)	RF Connectors and Impedance
261**	0.5 - 225	0 - 1000	Type 83-1R 52 ohms
262	-	0 - 1000 (relative)	Indicator only
263	0.5 - 225	0 - 10; 100; 1000	Type N* 52 ohms
702N	28 - 2000	0 - 4	Type N* 52 ohms
703N	20 - 2000	0 - 12	Type N* 52 ohms
▲705N	20 - 2000	0 - 120	Type N* 52 ohms
▲706N	28 - 2000	0 - 400	Type N* 52 ohms
711N	25 - 1000	0 - 30; 75; 300	N plus 83-1R Adapters
▲722N	1000 - 3000	0 - 4	Type N 52 ohms
▲723N	1000 - 3000	0 - 12	Type N 52 ohms
40588	28 - 2000	0 - 4000	1⅝" Flange 51.5 ohms
445A9	28 - 2000	0 - 12,000	3⅛" Flange 50.0 ohms
445A10	20 - 2000	0 - 40,000	3⅛" Flange 50.0 ohms

DC OUTPUT DIRECTIONAL COUPLERS

Model No.	Frequency Range (mcs.)	Power Range Incident & Reflected (watts)	RF Connectors and Impedance
576N1	42 - 2000	1.2	Type N* 52 ohms
576N3	20 - 2000	0 - 12	Type N* 52 ohms
▲576N4	46 - 2000	0 - 40	Type N* 52 ohms
576N6	28 - 2000	0 - 400	Type N* 52 ohms
▲592N	1000 - 3000	0 - 4	Type N 52 ohms
▲593N	1000 - 3000	0 - 12	Type N 52 ohms
40288	28 - 2000	0 - 4,000	1⅝" Flange 51.5 ohms
442A9	28 - 2000	0 - 12,000	3⅛" Flange 50.0 ohms
442A10	20 - 2000	0 - 40,000	3⅛" Flange 50.0 ohms

RF OUTPUT DIRECTIONAL COUPLERS

Model No.	Frequency Range (mcs.)	Coupling Attenuation	RF Connectors and Impedance
313N3	300 - 2000	30 db	Type N* 52 ohms
313N4	120 - 2000	40 db	Type N* 52 ohms
313N5	60 - 2000	50 db	Type N* 52 ohms
313N6	30 - 2000	60 db	Type N* 52 ohms
▲442A40	200 - 1000	40 db	3⅛" Flange 50.0 ohms

ABSORPTION TYPE RF WATTMETERS

Model No.	Frequency Range (mcs.)	Power Range (watts)	RF Connectors and Impedance
621N	1 to over 1000	0 - 120 milliwatts	Type N* 52 ohms
▲624N	1 to over 1000	0 - 4	Type N* 52 ohms
625C5	50 - 1000	0 - 120	Type C 50 ohms
▲651N	25 - 1000	0 - 25; 100; 500	Type N 52 ohms
▲611A7	50 - 1000	0 - 1200	3⅛" Flange 50 ohms
612A	44 - 1000	0 - 6000	3⅛" Flange 50 ohms

RF LOAD RESISTORS

Model No.	Frequency Range (mcs.)	RF Power Dissipation (watts)	RF Connectors and Impedance
633N	3000	50 (air cooled)	Type N* 52 ohms
635N	3000	200 " "	Type N* 52 ohms
636N	3000	600 " "	Type N* 52 ohms
636A	2000	600 " "	3⅛" Flange 50.0 ohms
638A	2000	6000 (water cooled)	3⅛" Flange 50.0 ohms

CALORIMETRIC TYPE Primary Standard of RF Power

Model No.	Frequency Range (mcs.)	Power Range (watts)	RF Connectors and Impedance
641N	0 - 3000	0 - 3; 10; 30; 100; 300	Type N 52 ohms

▲New products

*Also available with UHF, C, and HN Connectors.
**Coupler Unit Only for use with 262 Indicator.

M.C. Jones

M.C. JONES ELECTRONICS CO., INC.
BRISTOL, CONNECTICUT

Cohen (pictured on p 191) as vice-president and director of the newly expanded engineering division.

Cohen, formerly vice-president and chief engineer, is now responsible for all technical services to the corporation, including manufacturing processes, quality control and equipment design for all four of the company's operating plants in Jamaica, L. I., N. Y.

News of Reps

SYSTEMS control and data handling for the Beckman Systems Division is being handled by **LeeMark Associates,** engineering reps in Kansas, Missouri and Nebraska. A new Denver office extends technical liaison to the Colorado area.

Metallic rectifier manufacturer, Bradley Laboratories, Inc., New Haven, Conn., gives the nod to **John E. Boeing Co.,** Arlington, Mass., as New England reps.

Thermo Materials, Inc., Menlo Park, Calif., manufacturer of industrial ceramics, names six reps in the west. They include: **Cerruti & Hunter Associates,** Redwood City, Calif.; **Chafin & Champion Associates,** Los Angeles, Calif.; **Carl G. Chafin Co.,** San Diego, Calif.; **Charles Morrow,** Phoenix, Ariz.; **Paul Feeger,** Denver, Col.; and **Ed Brooks,** Albuquerque, N. M.

The Gilette Engineering Co. of Phoenix, Ariz., is appointed sales representative in Arizona and New Mexico for Westport Electric, El Segundo, Calif.

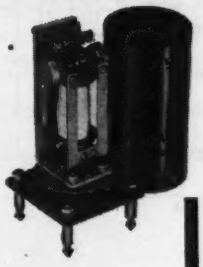
George W. Ledbetter and Associates is now the exclusive engineering sales representative for Ryan Industries Division in the states of California and Washington. The division, recently acquired by Lundy from Textron, Inc., makes chaff counter-measures systems and manufactures all the integral parts for this radar jamming device.

New rep firm, **Nelson Instrument Co.,** Evanston, Ill., offers sales and/or service representation in the midwest area covering Illinois, Wisconsin, Indiana and Iowa.

NOT A SUBSTITUTE!

here's the real thing . . .

The **KURMAN P255A POLAR RELAY**



- Unconditionally approved as an equal to the W.E. 255A by both Government and Industry.
- No modifications required for existing field equipment or techniques.
- No adapters necessary—standard connecting blocks available.
- Variations are available including ultra-sensitivity down to 5 micro watts.

IMMEDIATE DELIVERY FROM STOCK!

The complete line of Kurman relays, manufactured to commercial or military specifications, are interchangeable with other leading makes.

Send to Dept. E for complete catalog

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Division of Norbute Corp.
191 Newel St., Brooklyn 22, N. Y., EV 3-8000
Manufacturer of Quality Relays . . . Since 1926

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Men on the Move

Now available in a *new edition* . . . with *new figures.*

This popular booklet points up the important sales problem of personnel turnover in industry. Out of every 1,000 key men (over a 12-month period) 343 new faces appear . . . 65 change titles . . . 157 shift . . . and 435 stay put. These figures are based on average mailing address changes on a list of over a million paid subscribers to McGraw-Hill magazines.

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NOW we can meet the demand for

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THE METER OF PRECISION
METERS!
2" TO 7" SIZES

Expanded plant . . . increased staff . . . New, improved automation techniques . . . to meet the demand of electronic equipment manufacturers for custom produced panel meters, in production quantities.

PACE meters are manufactured under rigidly controlled climatic conditions to meet critical specifications as to sensitivity, resistance, damping, response time, illumination, scaleplate design, etc.

Send for latest illustrated catalog, available upon request.
Write, wire or phone for applications engineering, consultation and assistance!

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MOUNT VERNON, N.Y.
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Electroplated
WIRES
for many different applications
Continuous electroplating methods permit coating of many metals on to wire (or ribbon) in specified thicknesses of plate . . . This very flexible operation makes it possible to designate a desirable base or precious metal with a coating of another metal for its own particular characteristics. In our laboratory Tungsten wire as small as .00015" has been electroplated with Gold. . . . New combinations of plating on wire are being developed by our research staff from time to time. Your inquiry is invited.
Consult us, without obligation, about your specific wire problems.
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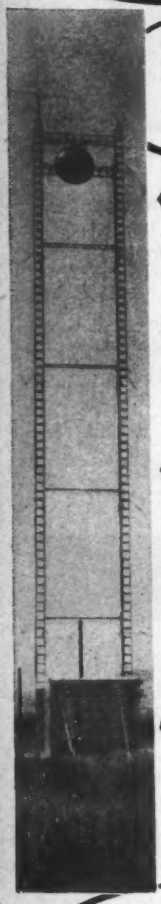

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NEW BOOKS

Television Engineering Principles and Practice Vol. II

By S. Ames and D. Birkinshaw *Philosophical Library, New York,* 1956, 268 *p,* $10.00.

This book is the second to appear in a series of four volumes planned by the British Broadcasting Corporation as engineering training manuals. Volume I, which was published earlier, treats such topics as fundamental television principles, camera tubes, television optics and electron optics. Volume III and IV, which are in preparation will cover waveform generation and a wide range of circuit techniques.

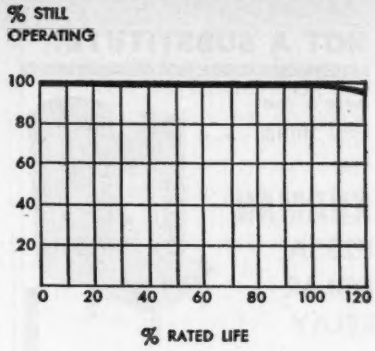
With this background, it is now possible to turn to a detailed consideration of Volume II. Since the book is devoted to video-frequency amplification in general, it will be of use to those engineers who are concerned with wide-band amplification or transmission problems. Further, an extensive mathematical background is not required for an understanding of the book. Simple derivatives are as involved as the mathematics becomes.

Video-Band Characteristics—The first chapters cover a discussion of the amplitude and phase characteristics of the video band and the effects produced by departures from the ideal. The simple R-C coupled circuit, effects on phase shift at high frequencies due to interstage shunt capacity, low-frequency phase shift, envelope-delay and square-wave testing are but a few of the topics discussed.

High-frequency compensation studies are confined to a thorough investigation of the shunt and series-inductance peaking circuits and various forms of cathode compensation.

Gain-Bandwidth product, cascading of stages, and distributed amplification are covered next. After this there is a very complete treatment of the design of passive phase equalizers in the lattice, bridged-T and T forms as well as the active derivative equalizer.

Following this is a treatment of



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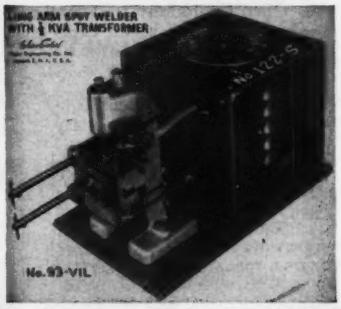

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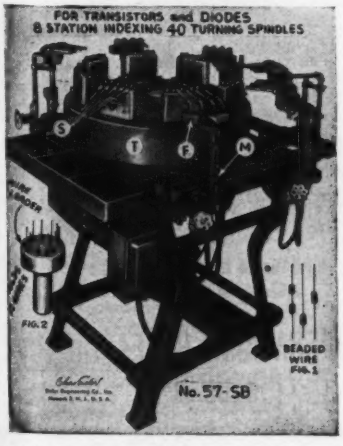

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various interstage coupling and decoupling procedures for low-frequency phase improvement. Included in these sections are uses of current feedback or degeneration for increasing the effective value of the grid resistor, various cathode, screen and plate decoupling circuits and d-c coupling methods.

Feedback—The final chapters concern basic principles of feedback, feedback in a single-stage R-C coupled amplifier and feedback in multistage amplifiers. Aperiodic voltage and current feedback, critical voltage and current feedback, maximal and optimal feedback calculations are some of the topics covered under basic principles. Instability and overloading in multistage feedback amplifiers is also treated.

Two chapters are included on sources of noise in video amplifiers and noise in camera head amplifiers.

The book is well written, has well chosen mathematical symbols and presents the material in a simple, easily understood, elementary fashion.

Two regrettable omissions, which seem quite glaring, are the use of the $\sin^2$ pulse for transient testing and the shunt-regulated video amplifier. Both of these subjects appear to have been well exploited in England. The $\sin^2$ pulse with great potential, which is just now beginning to be accepted in this country, has been known and utilized by Dr. Lewis and his associates at the Post Office Research Station for a number of years. In 1951, V. J. Cooper treated the shunt-regulated amplifier in *Wireless Engineer*. It is certainly hoped that Volume IV of this series will include these two topics.—*Ralph G. Kennedy, Adj. Assoc. Prof. Physics, Hofstra College, Hempstead, N. Y.*

Basic Automatic Control Theory

By Gordon J. Murphy.
D. Van Nostrand Co., Inc., New York, 1957, 557 p, $9.00.

This book is an attempt to provide a teaching text which integrates steady state sinusoidal and transient analyses of cybernetic devices. The author's approach, while not

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entirely novel, is, in major outline successful. It does represent modern design techniques, and on-the-job advantages can be predicted to accrue from welding mechanical and electrical viewpoints and terminology.

Particularly praiseworthy are the detailed treatment accorded and the excellent exercises which sample the problems involved in incorporating the approach and the field into one's thinking.

Topics—The subject material is restricted to the classically more fundamental topics in the treatment of linear servomechanisms with well-defined input data. There is no discussion of nonlinear techniques, sampled data systems, or statistical design principles as applied to cybernetic devices. Intended, as the author indicates, for undergraduate senior or first year graduate student level these limitations are probably well selected. The book serves well its stated purpose as an introduction to automatic control.

The pedagogic arrangement of the textual material is exemplified in the treatment of carrier type systems. Rather than store the material for separate discussion in one chapter, the author relies upon incremental learning and intersperses this material at appropriate spots of his discussions of components, block diagrams and compensating networks. In a comparable manner, the book discusses proportional, derivative and integral controllers, giving the reader insight into how the stabilizing networks he will meet later in studying Nyquist-Bode plots and root-loci achieve approximations to these ideal control characteristics.

Approach—Typical of the unified approach is the introduction of W-plane or Bode diagrams and Nichol's charts concurrent with discussions of the polar Nyquist plots. This simplifies the study of compensation in the real frequency domain and develops a clearer picture of the inter-relationship between the various stability criteria. In dealing with fundamentals, concepts of analogy are developed between mechanical, thermal, hy

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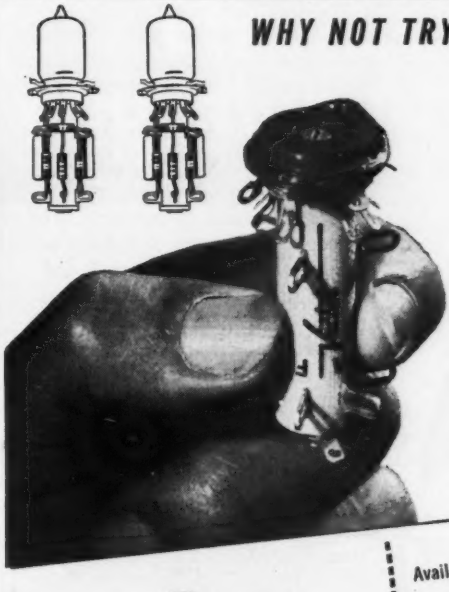

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draulic and electrical systems. These ideas are later applied in the study of stability and transient response.

In all, the book is recommended to the engineer anxious to develop a basic understanding of control systems and is well suited for adoption as a text in a senior undergraduate or first year graduate course in automatic control.—A. E. NASHMAN. *Executive Engineer, Guided Missile Laboratory, Federal Telecommunication Lab., Nutley, N. J.*

Theorie und Technik der Pulsmodulation

BY E. HOLZLER AND H. HOLZWARTH. *Springer Verlag, Berlin,* 1957, 505 *p, DM* 57.

THE introductory chapter to this work compares various types of modulation, amplitude, phase, frequency and pulse, and analyzes the qualitative characteristics of each type. Particular attention is paid to the several types of pulse modulation.

Mathematical Analysis—The second chapter treats the Fourier transform and LaPlace transform theory needed as fundamentals to the pulse modulation technique. The circuit elements for pulse modulation systems are considered in chapter 3 and the characteristics of pulse modulation networks are developed in chapter 4. Effects of noise is treated in chapter 5 and several pulse modulation systems are treated in the last chapter.

A fairly practical level is maintained throughout the book and the circuit engineer should find this work a useful introduction and a guide in the development of pulse modulation circuits and systems.—M. ETTENBERG, *Sperry Gyroscope Co. Div. of Sperry Rand Corp., Great Neck, N. Y.*

THUMBNAIL REVIEW

Repairing Hi-Fi Systems. By David Fidelman, John F. Rider Pub., Inc., New York, 1957, 212 p, $3.90. Troubleshooting and repairing audio equipment for technicians and audio enthusiasts.

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COMMENT

Credit Where Due

I read with interest the article "Crevasse Detector Blazes Glacial Trails" (Jan. 17, p 63), noting particularly the bridged-T transistor oscillator used in the main transmitter.

It is somewhat surprising to me that neither the author, H. P. van Eckhardt, nor your editors saw fit to give credit to the originator of the circuit, P. G. Sulzer of NBS. An article by Mr. Sulzer, containing virtually the same schematic diagram, appeared in ELECTRONICS in 1953 ("Low Distortion Transistor Audio Oscillator," Sept. '53, p 171).

An injustice would be done to the more recent author, however, if it were not pointed out that his circuit does contain one improvement upon the original. The capacitors shunting the 10K and 300 ohm collector load resistors accomplish a form of "dominant lag" stabilization against high-frequency oscillation. Such oscillation is otherwise a substantial problem when the circuit is constructed using transistors having better frequency response than those available in 1953.

WILLIAM L. PATERSON
INLAND TESTING LABORATORIES
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Gravity

Coupla months back thataway, there was quite an argument in the columns of "Backtalk" about gravity. These comments are among the late entries in the argument.

We propose a somewhat more fundamental approach.

Physicists have not only been baffled by the nature of magnetism and gravitation, but also by the bewildering array of "fundamental" particles (32), the astronomers' red shift, and the dual wave-particle nature of light. When a theory starts to get too complicated, it's time to be suspicious of its validity.

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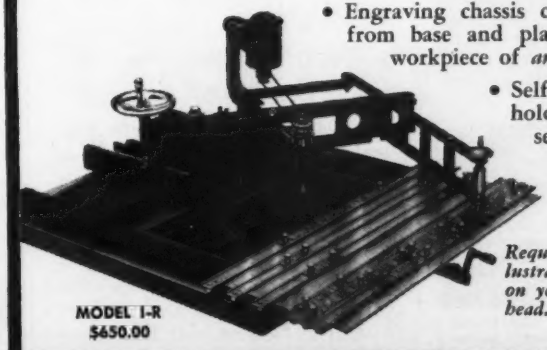
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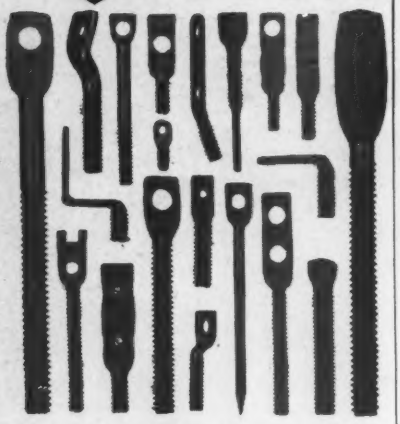

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age, chemists began to recognize the chemical elements as the "fundamental" particles of the universe. Then came isotopes and radioactive elements pointing to something even more fundamental. But why 32 of them?

Suppose we assume that corpuscular particles are atomic in structure and some simpler subcorpuscular particles are their building blocks. We could assume the ether to be a subcorpuscular gas. Hence light's dual nature and the maze of corpuscular particles might start to make a less confusing picture. We might then assume that magnetic and electrostatic fields are some sort of standing-wave field in this ether and gravitation a sort of vortex field.

If some physicist could find a way to split the corpuscular particles into pure energy, they might find something that would make the H-bomb look like a firecracker.

TED POWELL
42 NASSAU ROAD
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The question is always "How well do you know your physics?"

The essence of gravity has been capably dealt with by the late Albert Einstein. Some of us do not easily understand what Einstein had hold of.

Einstein pointed out that stars can be of a wide assortment in size, but there is a maximum limit. You cannot find a star whose diameter exceeds five light-hours Masses separated by a distance less than five light-hours attract each other; masses separated by greater distances repel and fly away from each other.

ESTEN MOEN
Box 693
CROOKSTON, MINN.

My congratulations to the original thinker who confessed to "abysmal ignorance" before jumping into this discussion.

To the rest of the hypothesizers I humbly suggest that four or five years studying the works of some of the minor intellects of the past —such as Newton and Einstein— who were also mildly aware of the problem might be in order.

JOHN COONEY
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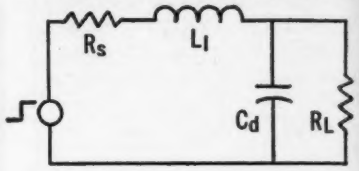
Pulse Notes

Control of Rise Time and Overshoot in Pulse Transformers

A pulse transformer with a turns ratio greater than unity ($n > 1$) can be approximated by the circuit below for the duration of the leading edge of the applied pulse.



Where R_S is the internal resistance of the pulse source, R_L load resistance, L_I and C_d, leakage inductance and distributed capacitance, respectively. If the transformer is matched ($R_S = N^2R_L$), this circuit is valid for step-up and step-down transformers.

Optimum step function response (minimum rise time and overshoot) occurs when $\sqrt{\frac{L_I}{C_d}} = R_L$. Under these conditions overshoot is approximately 4%; rise time from 10% to 90% of pulse height approximately equal to $1.52\sqrt{L_I C_d}$. If $\sqrt{\frac{L_I}{C_d}}$ is less than R_L, overshoot and ringing occur. Making $\sqrt{\frac{L_I}{C_d}}$ greater than R_L rounds the leading edge and increases rise time. Circuit designers should note that any shunt capacity in the load is effectively added to C_d which causes $\sqrt{\frac{L_I}{C_d}}$ to be less and overshoot greater than indicated by transformer specifications.

Leakage inductance and distributed capacitance are functions of winding geometry such as insulation pad thickness, wire spacing, and interleaving. These parameters must be accurately controlled during manufacture to meet rise time and overshoot specifications. In the Pulse Engineering Stat-Tran*, a rectangular coil form permits precise control of the winding configuration which contributes to uniform leading edge response.

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